POWER

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To Power Readers

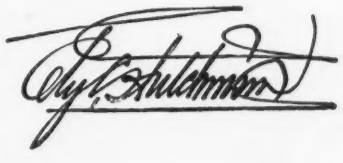
POWER, as a monthly journal of the power field, reconsecrates itself to the interests of power generation. Occasionally, one hears whisperings that the art of power production has so progressed that the margin between present day practice and perfection is not worth the price of attainment. But these are the views of the ignorant and the mentally stagnant.

No one familiar with the facts is so unconscious. Never have those in the field of power production been so vitally aware of its potentialities. Rest from the feverish building of new plants in the last year or two has given opportunity for calmer thinking and for the perfection of plans which guarantee a new era of power production and distribution.

In the new economy the isolated plant, with or without processing requirements and steam- or oil-operated prime movers, looms with increased importance.

Central station generation of power or steam for heating, with or without power as a by-product, will continue to grow. But the market for energy will depend more upon merit and price of service than influence and personality.

Power is keenly sensitive to these changes and the responsibility for keeping its readers abreast of all significant developments affecting their welfare. This and succeeding numbers will bear witness to the new spirit of power utilization and to a renewed determination of the editors to faithfully discharge their trust.



EDITORIALS

Who Will Crack This Bottle Neck?

SUPPOSE a man of key position in financial affairs and a director of industrial companies with money in the bank were told that his personal health could be greatly improved, and his earning capacity increased to the point where he would recover the price of the job in 16 months, if he would submit now to a safe operation on his gall bladder or whatever it is. Would he be likely to answer that, poor as his physical condition was at present, he felt that it might be even more critical in 1933, so he preferred not to spend the price of the operation now?

Silly as it sounds, this reasoning closely parallels a case recently enacted. But for the fact that the "body" happens to be an important industrial plant and the "operation" a relatively simple case of power plant modernization, the analogy is accurate. If this were the only one of its kind it would not be worth talking about. But it is indicative of the kind of reasoning at present in many businesses under banker influence.

Power engineers are energetic, clear-thinking men who have amply demonstrated their ability to lead the way to savings by modernization. But they cannot do their work alone. With each succeeding day it looks as though the committees, set up by Owen D. Young to work with the Federal Reserve Banks, are the only groups with strength to crack these bottle necks so seriously restricting the return to normal conditions. Everyone with a case should report it to his nearest committee.

Refrigeration-Heating Makes Headway

An article in this number gives the results of tests made at Los Angeles on the first large-size installation of refrigeration-heating. The data secured indicate that for each kilowatt of electric energy utilized, close to twice the heat equivalent of a kilowatt is available for heating the building. With this performance ratio five-mill power is about equivalent to coal at ten dollars a ton.

This system of heating, which transfers heat from the outside air to the air in the building, is applicable only in climates that rarely experience freezing temperatures, because the performance ratio and heating capacity decrease with lower outside temperatures. Also at temperatures below freezing, trouble from frost on the heat-absorbing coils will probably be encountered. Although these considerations largely eliminate the use of refrigeration-heating in the more northern climates, nevertheless there remains a large section in the South where this method of heating is better adapted.

Air conditioning of buildings is required to a greater extent in the warmer sections of the country, and the refrigerating equipment installed for the purpose can, with little additional expense, be used for heating the building in cold weather. Under these conditions the fixed charges on most of the equipment are chargeable to air conditioning and not to building heating, making the use of this system an economic possibility.

As the Los Angeles installation is the first of this type it is reasonable to expect improvements in the performance ratios obtainable in future installations.

Saving the Kilowatts That Cost More

Electric utilities have long recognized the fact that some kilowatts cost more than others. By "demand charges" they penalize the peak loads that pile up investment in their generating stations. In the sale of "byproduct" power to factory departments, industrial power plants face a somewhat similar problem, but one more difficult to solve.

In most process plants there are periods when the power demand exceeds the process load. The moment the point of balance is passed each additional kilowatt of load represents from 2 to 6 lb. of coal instead of ½ lb. for the straight "byproduct" power output.

At present there is no appreciable incentive for any factory department to economize on electrical consumption during these periods of high power cost. Its savings would only be buried in the "average" kilowatt-hour cost and so distributed to all departments.

If any reader has worked out a practical solution of this problem *Power* will be glad to learn of it and to pass the idea along to others who could use it to save fuel dollars.

Resilient Material for Turbine Blades

Difficulty is still experienced with erosion by moisture in the last rows of steam-turbine blading. Several schemes have been tried to remove the moisture in these last stages; sometimes with fair success, sometimes not.

Heavy round-edged blade sections have replaced the earlier feather-edged blades for this service. Also,

the search for better materials continues. Stainless steel, Nitralloy, heavy chromium-plated steel and welded-on overlays of tungsten and tantalum carbides and Stellite are under trial. The effort so far has been to perfect an ultra-hard erosion-proof surface.

Why not reverse the idea and develop a material with the desirable erosion resistance of rubber or some of its newer inorganic substitutes, but without their undesirable characteristics? Rubber itself has proved singularly successful in pipe-line service and in pumps where hot erosive materials are handled, but it has not yet been so treated as to make it sufficiently heat-resistant for turbine service. Inorganic substitutes thus far have similar limitations. The earlier difficulty of obtaining a good joint between rubberlike materials and steel has been solved where ordinary temperatures are involved. Why should not the next step be the discovery of a higher temperature bonding and a method of treatment to increase heat resistance?

Economies Lurk in Hidden Places

Low-cost lubricants are not necessarily the least expensive in the long run. To all exterior appearances a bearing may be performing nicely, but how about the power absorbed by friction?

A sweet-running bearing is always cool, but with water cooling used in many of the important places it is not easy to recognize an excessive friction load by ordinary methods.

Considering that the annual cost of lubricating a fifteen-thousand kilowatt hydraulic turbine, including labor and material, is reported at one hundred and forty-five dollars, one can see that primary power consumed by excessive friction, whether from mechanical causes or improper lubricant, can quickly outweigh the apparent saving in lubricating cost.

Instruments are at hand with which to investigate these hidden losses, and their makers are busy.

Be Spare with Spare Capacity

It is surprising to find how many of the engineering ideas of yesterday are old-fashioned today. Under stress of absolute necessity for economy, many of the things blindly regarded as fixed essentials have since been ruthlessly dumped overboard. And we suddenly discover we are suffering no disaster.

The "spare capacity" idea is one of these. Undoubtedly there are still places where engineering considerations demand certain spare equipment to care for emergencies. But that does not mean, at all, that the rule is universal.

Where unnecessary spare apparatus is eliminated the reduction in capital cost and operation expense is frequently the balance which determines whether the installation of the plant is economically warranted.

Those genuinely interested in cheap power will carefully guard against uselessly loading estimates with equipment that does not earn its right to be among those economically present.

Men to Fit the Job

Plant operation is getting more technical. It is also getting more practical, as evidenced by the stress laid on dollar balance. Power cost sheets are seen everywhere.

This trend points the way to the specifications of the future power engineer: He will have, first, the practical "know how" of keeping power men and power machines on the job; second, a fundamental knowledge of the technical elements involved in equipment selection, hookup and operation; third, the ability and willingness to chase power dollars—everlastingly.

Wherever there is much money to be saved by the practical application of brain and skill, good jobs are waiting for the right men. The power field fits this picture.

When Steam Sets Fire to Oil

In this number is reported a serious fire at the Bremo Bluff Plant of the Virginia Public Service Company. It was caused by ignition of turbine lubricating oil from a broken pipe line coming in contact with a high-temperature steam pipe. This is the second such accident in a central station, and in both cases the fire spread to the turbine lubricating oil reservoir located under the turbine-room floor.

These two almost identical and unprecedented accidents occuring in new high-temperature plants indicate a hazard not ordinarily suspected in plant design. The news now comes out that lubricating-oil line failures have occurred from time to time. They resulted in little damage, and were therefore not reported to the technical press, nor was anything done to prevent their occurrence in other plants. Had it been generally known that oil-line fires occasionally happen, designers would undoubtedly have made provision to prevent the spread of oil and fire to the reservoirs. In this way a considerable part of the damage in these two cases could have been avoided—and designers and operators might have been better and sooner warned.

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POWER Stands for . .

1. Making Power When It Should Be Made
2. Buying Power When It Should Be Bought
3. Cheaper Power Through Modern Equipment
4. Easier Financing of Equipment Purchases
5. Better Use of Byproduct Heat and Power
6. Operating Methods That Save Money
7. Less Waste in Transmission and Application
8. Prevention of Smoke, Within Reason

MACY'S PLANT DOUBLES OUTPUT REDUCES FUEL COST

Power generating units consist of 3,350 kw. of steam-engine generators, two 700-kw. diesel-engine generators and two 410-hp. exhaust-steam turbines driving refrigerating compressors. In 1924 the plant generated 7,535,933 kw.-hr. and last year 15,905,704 kw.-hr. for slightly less fuel cost. Estimated saving for 1931 is $101,141

Macy's store from the corner of 7th Ave. and 34th St., New York City

MACY'S department store in New York City has been increased more than 100 per cent in floor area during the last ten years and is now the largest store of its kind in the world. It has a floor area of 2,041,335 sq.ft. and occupies practically the whole block bounded by Broadway, Seventh Avenue, 34th and 35th Streets. Enlarging the store made it necessary to extend greatly the power services. To do this the power-plant capacity has been increased about 150 per cent, with practically no increase in space for power-generating and distributing facilities.

This plant has many features. In its development it has been given unusually careful engineering study, both by consulting engineers and by Macy's operating engineering staff. Every change in the plant has been made only after exhaustive study has shown it to be the most economical when compared with all other means of providing the service.

Electricity is generated by a combination of steam and diesel engines that gives an economical heat balance and makes for low operating cost. In addition to the power-generating plant, two 410-hp. exhaust-steam turbines drive the compressors for the air-conditioning system. With a normal capacity of 4,750 kw., this is one of the largest department store power plants in the world. By slight changes in the diesel engines, 250 kw. of additional capacity can be obtained, the generators having been designed with this possibility in mind.

The plant operates at the capacity factor of 38.45 per cent which is unusually high for stations of this class. During the peak periods of the year the generating equipment operates nearly 100 per cent loaded through the business hours.

The Macy plant is operated as part of the business and not as something alien to it. For the space it occupies in the building, it is one of the best paying departments in the store when compared with other means of supplying the power and the steam requirements.

When the store expansion program was initiated in 1920 one of the first problems to be solved was a power supply for the new building. Two firms of consulting engineers were employed, Werner Nygren on the steam supply and Kaiser Muller & Davies to study the power problem. After an exhaustive investigation of the different possible ways of supplying steam and power it was decided to enlarge plant capacity, which could be done in the space occupied by the old installation.

The power plant in the subbasement of the old building had a capacity of 2,000 kw., consisting of four 400-kw. corliss engines driving 120-volt two-wire direct-current generators and two 200-kw. units. Steam was supplied by eleven coal-fired water-tube boilers having a total heating surface of 30,000 sq.ft. This plant, although twenty years old, was in excellent condition and was supplying power and steam at an annual cost

much less than that for which it could be purchased.

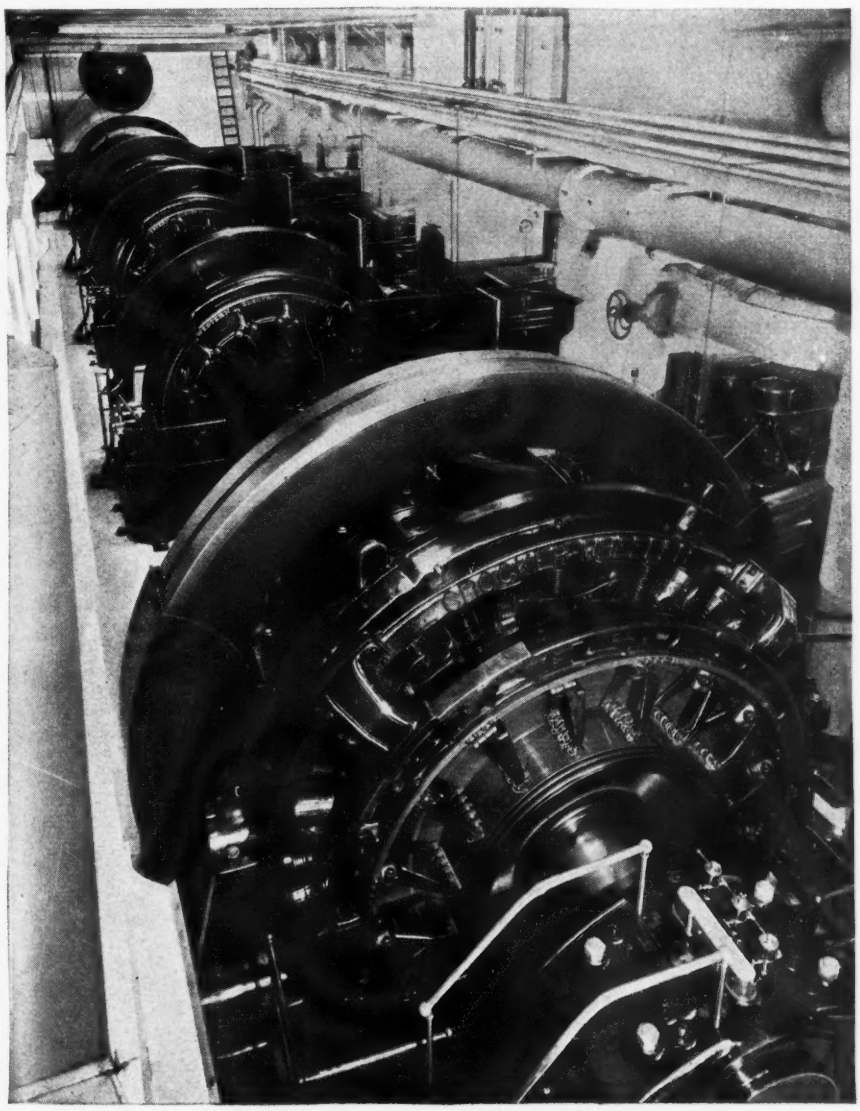
The engineering studies showed that it would be economical to change the boiler furnaces from coal to oil firing, on a basis of existing oil prices. The change-over was based on coal at $6.70 per ton and oil at four cents per gallon, both delivered in the plant's bunkers. To insure the economic success of oil burning a two-year contract was obtained before the change was made. It was estimated that the saving in fuel and operating costs with this price for oil would pay for changing from coal to oil firing and back to coal, if the oil contract could not be renewed at a favorable price. This change-over has been highly profitable because of the continuing low price of oil, the increase in boiler capacity, the more economical plant operation, and the elimination of ash-removal costs and nuisance.

As already mentioned, the old power system was of the 120-volt two-wire design. When the engineering studies were being made for enlarging the power supply it was decided that the distribution system should be changed from two-wire to 240- and 120-volt three-wire. This was desirable because of the reduced cost for conductors in the new building and any future extensions that might be made to the store. Moreover, if it became desirable to purchase power, the building distribution system would be suited to that service.

To make the change-over required rebuilding the switchboard and rewinding the four 400-kw. generators. The wiring on the switchboard was transferred to a temporary board, and as the generators were reconditioned the distribution system was changed and both transferred to the three-wire system on the permanent switchboard. This change-over was made with the normal load on the plant and without interrupting any of the services to the store.

The two-wire system in the old store was not interfered with, but the circuits were distributed on the new three-wire supply so as to obtain approximately a balanced load. Some of the two-wire circuits are connected to double-throw switches so that they may be transferred to either side of the system. With a load of 18,000 amp. on the plant it is possible to keep the load balanced within 100 amperes.

The two 200-kw. generators were driven by piston-valve engines. Removal of these two units provided space for installing a 750-kw. and a 250-kw., 250-volt two-wire corliss-engine-driven generator. This change increased the plant capacity by 600 kw. As an initial step in changing over to the three-wire system three motor-generator three-wire balancer sets were also installed. When part of the load had been transferred to the new units the old machines were rewound, one at a time, for 250 volts and put into service on the new system, the load being transferred as machine capacity was made available.

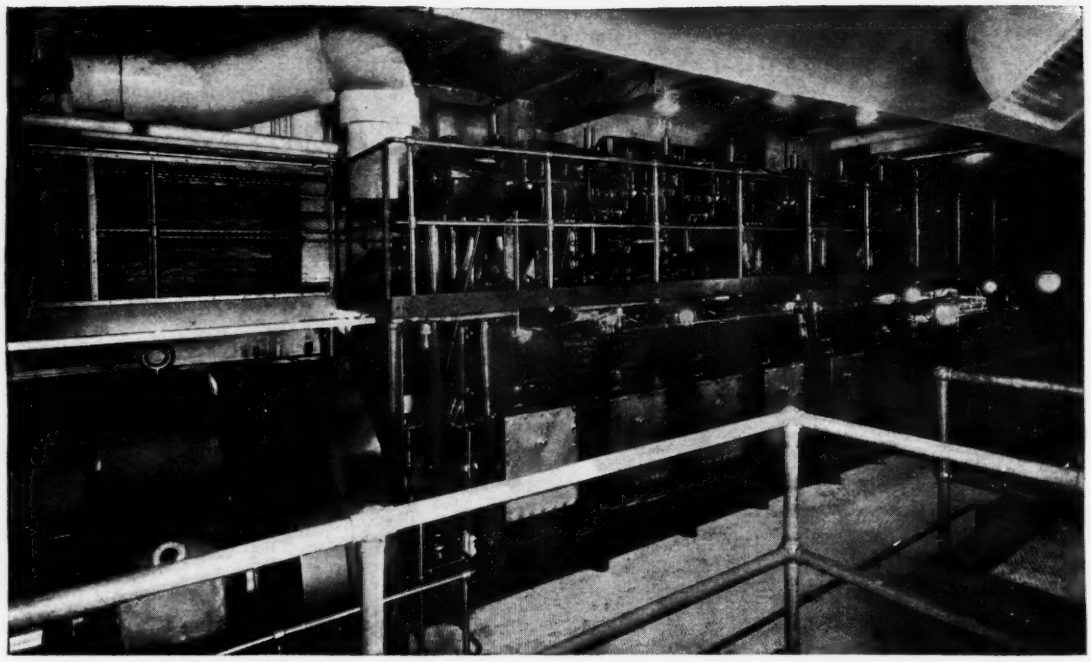


The steam-engine plant has a capacity of 3,350 kw. and operates on a steam rate of 32.6 lb. per kilowatt-hour

The four 400-kw. corliss engines, although they had been in service for 20 years, were in practically as good condition as when installed, except that the valves were a little worn. These engines could have given several years more service before it would have been necessary to recondition them, but because the engines were shut down for rewinding the generators it was decided to overhaul them at once.

At that time there were twenty-six hydraulic elevators in the old store, supplied by two steam-driven pumps. By installing motor-driven centrifugal pumps for the elevators, the old steam pumps could be removed. This left space for another 750-kw. corliss-engine-driven generator. Besides, changing from steam- to motor-driven pumps improved the efficiency of the plant. The 750-kw. machine was installed, bringing the capacity of the plant up to 3,350 kw., sufficient to care for the power requirements of the old and the new store.

Handling of rubbish, such as waste packing material from the different departments, had always been a sore spot in the smooth run-



One of the two 1,000-hp. diesel-engine generating units that operate on a fuel consumption of 0.644 lb. per kw.-hr.

ning of the store's regular business. Waste paper was collected, baled and sold, but this was always a questionable transaction economically; besides, the shipments interfered with other work on the loading platforms.

In view of the expected increase of waste materials from the new store an incinerator was installed to handle all of it. This incinerator contained an economizer connected in the boiler feed-water line between the feed pump and the boiler. Thus much of the heat from burned rubbish is recovered. The incinerator was designed to burn 1,600 lb. of rubbish per hour but has burned as much as 6,000 lb.

Business increased steadily and a second incinerator became necessary to burn the rubbish in rush seasons. Since this incinerator is not in continuous operation it has not yet been equipped with an economizer.

After several years of engineering and economic studies it was decided in 1928 to condition the air during the summer months on the main and basement floors. Because of the unexpected growth of the store's power load, plant capacity was not available to drive the refrigerating machines of the air-conditioning system. To drive these machines from either electric power or steam supplied from the store's plant would require an extension of these facilities. Alternatives were to purchase power, or to use low-pressure turbines operated on exhaust of the engines.

The exhaust-turbine arrangement was selected as more economical. Two 350-ton low-pressure centrifugal refrigerating machines were installed, each driven by a 410-hp., 3,750-r.p.m. turbine. The turbines exhaust into surface condensers at a vacuum of about 25 in. Condensing water is taken from the city mains, and discharged to the sewer. This water first passes through the condensers of the refrigerating machines before going to the surface condensers on the steam turbines. Much of this water would be required even if the compressors were driven by motors. Consequently the steam turbines are operated on what would otherwise be waste in the summer months—exhaust steam from the power plant and water from the air-conditioning system.

Because the load increased beyond expectation the back pressure on the engines became higher in the summer months than had been intended, due to the fact that the exhaust pipe was designed for a considerably smaller load. The installation of exhaust-steam turbines has reduced the back pressure on the engines and improved their steam rate. At times a slight vacuum exists in the exhaust line at the engines.

In 1928, when the remainder of the block was taken over with the intention of further enlarging the store, the problem of power supply to the proposed extension again presented itself. Both the boiler plant and the power-generating units were loaded to nearly full capacity. This made it necessary to consider extending the plant or purchasing power. Because of space limitations it would have been difficult to extend the boiler plant to take care of additional steam-engine-driven generators. Consideration of several plans showed that the new load could be most economically supplied by installing two diesel-engine-driven generators.

At this time all the old hydraulic passenger elevators were replaced by electric elevators. Thus the space in the power plant occupied by elevator surge tanks and pumps became available for installing the diesel units.

Several considerations made the diesel units preferable for the new extension. First, they permitted the installation of maximum power in the space available. They would materially improve the economy of the plant, particularly since the steam plant delivered enough exhaust steam for heating and other purposes during most of the year. The engines would provide an entirely separate power source other than the steam plant and would therefore increase the reliability of the station.

At that time, experience with diesel engines in public buildings, both in this country and in Europe, had proved that they could be installed so as to operate without causing inconvenience due to vibration or noise in the building. It had also been proved that they could be expected to operate with a high degree of reliability. The two latter considerations were of primary importance, because of the proposed location of the engines and the small margin of spare capacity.

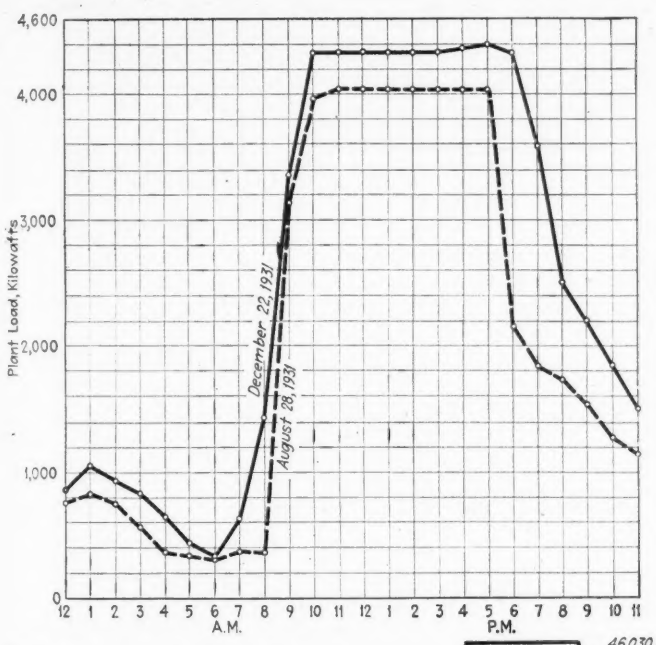
Two units were installed, each consisting of a 1,600-hp., 8-cyl., 4-cycle, trunk-piston, air-injection, 225-r.p.m. diesel directly connected to an 800-kw., 250-volt generator. The two units are installed in a space about 90 ft. long by 16 ft. wide and with 16 ft. headroom. Approximately 15 per cent more generator capacity is provided than would normally be needed for the engine's capacity. It is expected that, by equipping the engines with superchargers at some future date, they can be made to drive the generators at full capacity. The limited space in the sub-basement for future plant extensions was one of the reasons for providing for the superchargers, it being desirable to get all the power-generating capacity possible in the available space for its installation.

These engines have been in service for nearly two years and have given satisfactory service. They are located just below floor space where merchandising is done, yet their operation is not noticeable outside the engine room. As expected they have improved the plant's efficiency. In 1932 these units generated 3,757,090 kw.-hr. on a fuel consumption of 0.644 lb. per kw.-hr., as compared to 2.295 lb. per kw.-hr. for the steam units.

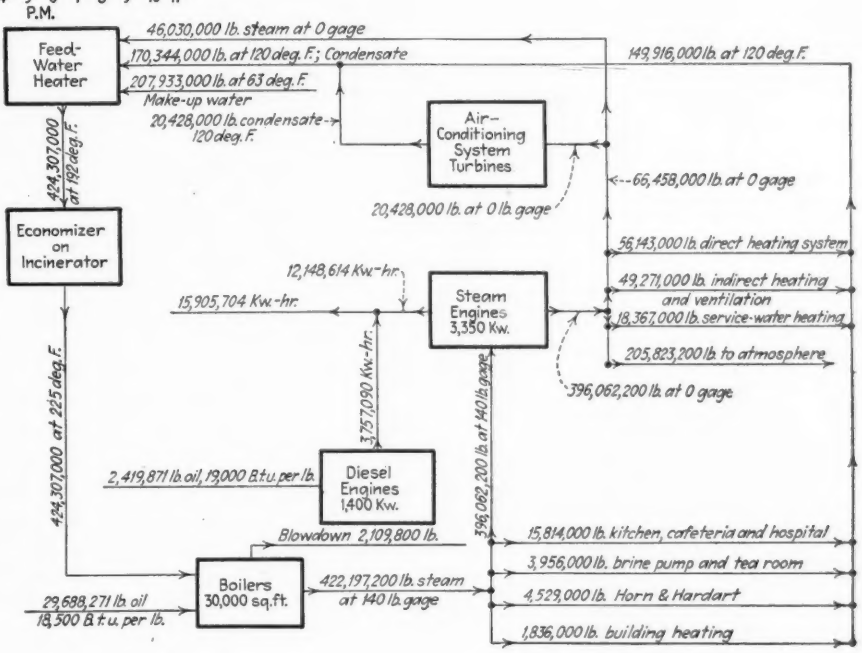
In 1931 the plant generated 15,905,704 kw.-hr.; 12,148,614 kw.-hr. was produced by steam-engine-driven units and 3,757,090 by diesel-engine units. Since 1924 the kilowatt-hour output of the plant has more than doubled. In that year, 7,535,933 kw.-hr. were produced, which is 47.4 per cent of the 1931 output. In 1924 for power generation, 2,539,233 gal. of fuel oil was burned under the boilers; in 1928 the oil burned was 2,803,286 gal. and in 1931 the oil consumption for power was 3,772,777 gal. This is the equivalent of 2.92 kw.-hr. in 1924, 3.36 kw.-hr. in 1928, and 4.22 kw.-hr. in 1931 per gallon of oil burned. The large increase in power per unit of fuel from 1928 to 1931 reflects the economy of the diesel engines. Because of the improved economy and better fuel price the fuel cost for power in 1931 was $2,096 less than in 1924, in spite of the fact that the 1931 power output was more than double that of 1924.

The effects of the diesel engines are also reflected in the cost of power for the years 1928 and 1931. In the former the cost per kilowatt-hour was 1.603 cents and in the latter 1.492 cents. The 1931 cost includes a capital charge of $69,120.45, representing 7 per cent interest and 5.5 per cent depreciation on an appraised plant value of $552,963.57 as made by Lockwood Greene, Engineers, Inc. The cost of power also includes all other plant operating and maintenance charges and rental for the space occupied by the equipment. Based on a purchased power cost at the low cost of 1.594c. per kw.-hr. and a purchased steam cost of 74.3c. per 1,000 lb. it is estimated that operation of the plant in 1931 saved $101,141 as compared with the cost of purchasing power and steam for the store.

Figured on the basis of the floor area, 29,230 sq.ft., occupied by the power-generating equipment, the saving resulting from operating the plant in 1931 amounted to $3.46 per sq.ft. If all plant equipment space, 46,200 sq.ft. of floor area (including space occupied by the air-conditioning equipment, refrigerating plant, vacuum-cleaning machines, cash-conveyor-system blowers, service and fire pumps and other equipment that has nothing



Plant load curves; one for the maximum winter peak and another for normal summer load. Both of the curves have an unusually flat peak for 7 to 8 hr. per day. The peak of the winter curve extends for about one hour longer than that of the summer curve. This is due to the Christmas holidays when the store is kept open longer than normally


Feed-Water Heater
46,030,000 lb. steam at 0 gage
170,344,000 lb. at 120 deg. F.; Condensate
207,933,000 lb. at 63 deg. F. Make-up water
20,428,000 lb. condensate-120 deg. F.
149,916,000 lb. at 120 deg. F.
Air-Conditioning System Turbines
424,307,000 at 192 deg. F.
66,458,000 lb. at 0 gage
20,428,000 lb. at 0 lb. gage
Economizer on Incinerator
56,143,000 lb. direct heating system
12,148,614 Kw.-hr.
49,271,000 lb. indirect heating and ventilation
15,905,704 Kw.-hr.
Steam Engines 3,350 Kw.
18,367,000 lb. service-water heating
205,823,200 lb. to atmosphere
396,062,200 lb. at 0 gage
3,757,090 Kw.-hr.
424,307,000 at 225 deg. F.
2,419,871 lb. oil, 19,000 B.t.u. per lb.
Diesel Engines 1,400 Kw.
396,062,200 lb. at 140 lb. gage
Blowdown 2,109,800 lb.
15,814,000 lb. kitchen, cafeteria and hospital
3,956,000 lb. brine pump and tea room
Boilers 30,000 sq.ft.
422,197,200 lb. steam at 140 lb. gage
29,688,271 lb. oil 18,500 B.t.u. per lb.
4,529,000 lb. Horn & Hardart
1,836,000 lb. building heating

Approximate heat-balance diagram for 1931. In this diagram no account is taken of the various losses nor is credit given for hot-water drips to the feed-water heater. All high-pressure steam quantities are metered but the low-pressure quantities are based on estimates made in engineering studies of the requirements

RESUME OF PLANT OPERATION IN 1931

Total steam produced, lb.	422,197,200
Fuel oil burned, lb. (boilers)	29,688,271
Heat value of fuel oil, B.t.u. per lb.	18,500
Water evaporated per lb. of fuel, lb.	14.22
Boiler and furnace efficiency, per cent	76
High-pressure steam used for building heating and miscellaneous purposes, lb.	26,135,000
Steam used in engines, lb.	396,062,200
Kilowatt-hours generated by steam	12,148,614
Steam at 140 lb. gage, no superheat, lb. per kw.-hr.	32.6
Fuel oil per kilowatt-hour, lb	2.295
Fuel consumed by diesel engines, lb.	2,419,871
Kilowatt-hours generated by diesel engines	3,757,090
Oil per kilowatt-hour, lb.	0.644
Cost per kw.-hr. steam and diesel, including all operating charges, interest, depreciation and insurance, but without giving any credit for exhaust steam for heating and power-purposes, cents	1.492
Exhaust steam used for building-heating systems, lb.	105,414,000
Exhaust steam used by air-conditioning plant turbines, lb.	20,428,000
Exhaust steam used for service-water heating, lb.	18,367,000
Exhaust steam for feed-water heating, lb.	46,030,000
Live steam used for heating and cooking	26,135,000
Estimated cost of purchasing power at 1.594c. per kw.-hr.	$253.541
Estimated cost of purchasing steam, to replace that used for heating purposes and to drive the compressors on the air-conditioning system at 74.3c. per 1,000 lb.	$126.635
Actual cost of supplying power and steam from Macy's power plant	$279,035
Estimated savings for 1931 from operating the power plant	$101,141

to do with power generation) is considered, the saving per square foot of area is $2.18.

The Macy store has a total area of 2,041,335 sq.ft., and over 1,000,000 sq.ft. of space in other buildings is used for storage, shipping and other purposes, making a total of 3,041,335 sq.ft. devoted to merchandising, that in 1931 made a net profit of $4,930,767. This is equivalent to $2.42 per sq.ft. of floor area, compared to $3.46 saved per sq.ft. of floor area occupied by the power-generating equipment. If the earnings per square foot of merchandising floor area had equalled the saving per square foot of floor used for power generation in 1931, the net earnings of the store would have been over $10,500,000.

The chief components of power load are 56 elevators and 56 escalators, 1,730 hp. of motors on the heating, ventilating and air-conditioning systems, 250 hp. of motors in the refrigerating plant, 440 hp. of motors on the pneumatic-tube system, about 110 motors on the conveyor system, a large electric-truck battery-charging installation and a 2,000-kw. lighting load.

The plant factor is unusually high for a load of this kind. There is an installed capacity of 4,750 kw., which if kept fully loaded for 24 hr. per day, 365 days per year, would generate 41,525,400 kw.-hr. The plant actually generated 15,905,704 kw.-hr., giving a plant factor of 38.4 per cent. A plant factor of 41.4 is obtained for the steam-engine generating equipment and 30.6 for the diesel engines. The latter are operated at approximately full load from about 9 a.m. to 6 to 10 p.m., the off-peak load being supplied by the steam plant, to take care of heating requirements.

As can be seen from the load curve, the load for about 8 hours of the day is unusually constant and is well up toward the capacity of the plant. As a result of the rapid growth in load the power plant has been operated for the last 10 years with very little reserve capacity. Frequently it has been necessary to have all generating equipment in service to carry the load.

There is a large load of ventilating fans and other equipment that can be disconnected in an emergency, should a unit fail. However, the fact that such an emergency has never developed suggests this interesting question: Is the large reserve provided in some building plants actually required, or is it an unnecessary expense? The fact that the plant can be operated with so little reserve capacity and give 100 per cent service bespeaks the good design of the plant and equipment and the high standards of operation.

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POWER'S HISTORY

POWER was founded in 1884 by E. P. Harris and H. M. Swetland. With it was incorporated *Steam*, which had been started by N. Hawkins in Chicago two years earlier.

In 1903 *Power* purchased and absorbed *Science and Industry*, which was a consolidation of a number of periodicals, namely, *Home Study Magazine, Home Study for Machinists, Mechanic's Magazine, Home Study for Building Trades, Building Trades Magazine, Home Study for Electrical Workers* and *Steam Electric Magazine.*

In 1908 it absorbed *The Engineer's Review*, of Cleveland, and *The Engineer*, of Chicago, the latter being a consolidation of *The Safety Valve, Lord's Power and Machinery Magazine, The Stationary Engineer, Engineers and Power Users Magazine, Steam Engineering* and *The Mechanical Engineer.* When *The Engineer* was purchased the name of the combined paper was *Power and The Engineer.* The title was condensed to *Power* in 1911.

Ownership of *Power* passed from E. P. Harris to H. M. Swetland and James H. McGraw, then to John A. Hill; and with the consolidation of the Hill Publishing Company and the McGraw Publishing Company, in 1917, it became the property of the McGraw-Hill Publishing Company.

Robert Grimshaw was the first editor of *Power.* Subsequent editors for short periods were George L. Fowler, A. D. Risteen and Franklin Van Winkle. F. R. Low was editor from 1888 until Dec. 31, 1929.

The present staff consists of Ely C. Hutchinson, editor; F. R. Low, editor emeritus; P. W. Swain, F. A. Annett, R. B. Purdy and E. J. Tangerman, editorial staff.

Chart Sums Up Year's Operation

By H. EMERSON HILL
Maintenance Engineer
Southbridge, Mass.

INDUSTRIAL managers, consultants and accountants, as well as power engineers, can make good use of a simple yearly summary of power-plant operation. While there is no one best way to present this information, the writer feels that many power engineers and other industrial executives will be interested in the accompanying chart and tabulation prepared for this purpose. These show where steam and electricity are generated and where they are used.

From the diagram a consulting engineer may at once get useful data for his estimates on plant operation and efficiency. From it the plant accountant, already in possession of the data on fixed charges, may get his figures for establishing rates for kilowatt-hours and steam. The management can get a clear general picture of plant operation.

If a chart of this type is colored, as indicated by the key on the legend, it is much easier to follow.

STEAM PRODUCTION AND DISTRIBUTION — 1931

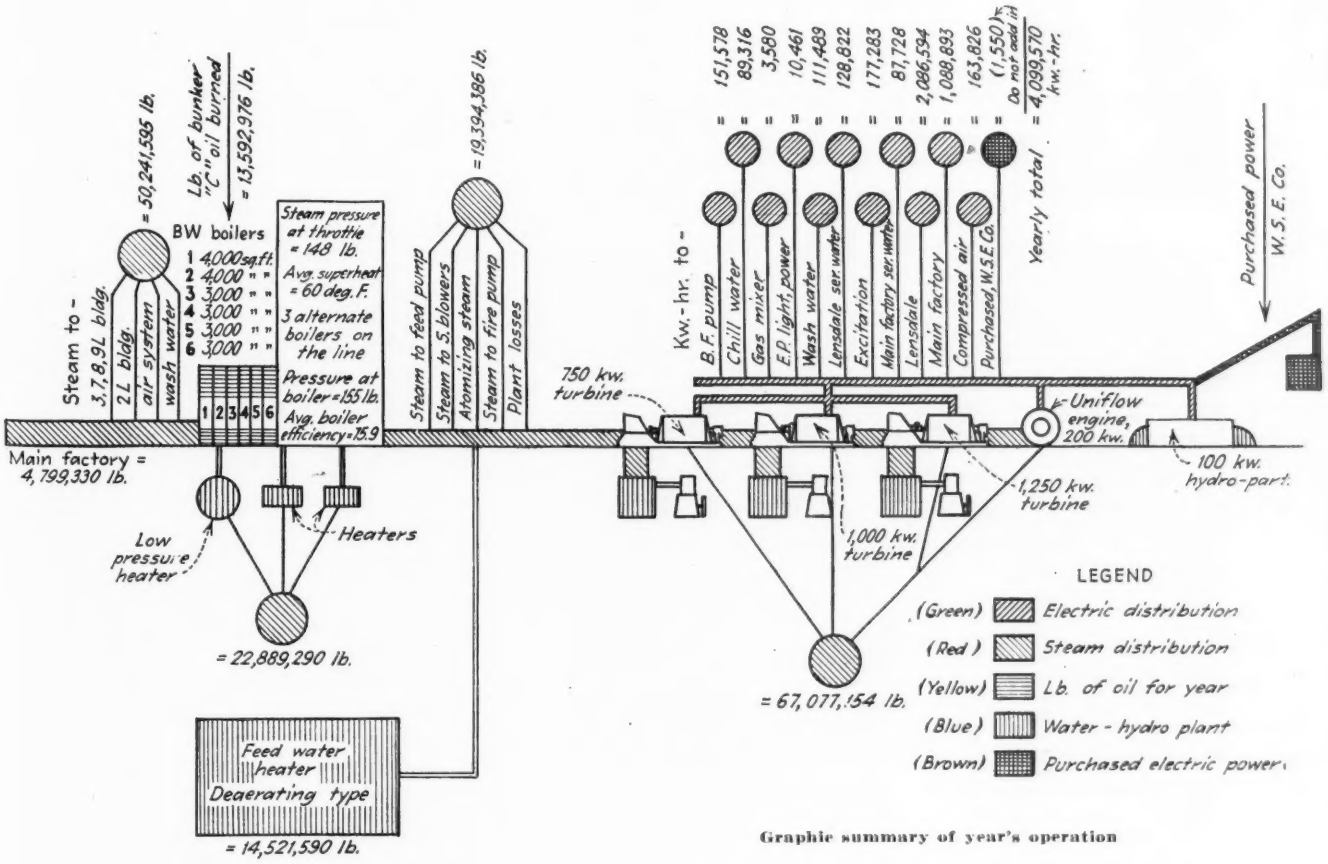
	Lb.
Steam to turbines	61,744,292
Steam to uniflow engine	5,332,862
Total steam to electric power	67,077,154
Steam to atomize fuel oil	9,984,947
Steam to E. P. station auxiliary	9,409,439
Steam to heating feed water	14,521,590
Steam to Lensdale 3, 7, 8, 9-L	39,765,845
Steam to Lensdale 2-L	2,649,180
Steam to heating wash water	7,826,570
Steam to heating buildings, No. 1	11,048,353
Steam to heating buildings, No. 2	11,840,937
Steam to main factory	4,799,330
Total steam generated	178,923,345
Gallons of oil burned	1,662,844
Pounds of oil burned	13,592,976
Average evaporation, lb. per lb. oil	13.2
Steam per kw.-hr.	17.4
Feed water average temp., deg. F	197
Steam temp., deg. F	425
Average boiler efficiency	75.9

POWER PRODUCTION — 1931

Kw.-hr. by turbines	3,172,480
Kw.-hr. by uniflow engine	697,830
Total kw.-hr. by steam	3,870,310
Kw.-hr. by water wheel	227,710
Total kw.-hr. generated	4,098,020
Power purchased W. S. E. Co.	1,550
Total kw.-hr. used	4,099,570
Kw.-hr. used by exciters	177,283
Net generated	3,922,287

POWER DISTRIBUTION — 1931

Kw.-hr. for boiler feed pump	151,578
Kw.-hr. for E. P. Light & Power	10,461
Kw.-hr. for compressed air	163,826
Kw.-hr. for chill water	89,316
Kw.-hr. for gas mixer	3,580
Kw.-hr. for pumping wash water	111,489
Kw.-hr. for pumping service water, Lensdale	128,822
Kw.-hr. for pumping service water, main factory	87,728
Kw.-hr. for main factory	1,088,893
Kw.-hr. for Lensdale factory	2,086,594
Total distribution	3,922,287



Graphic summary of year's operation

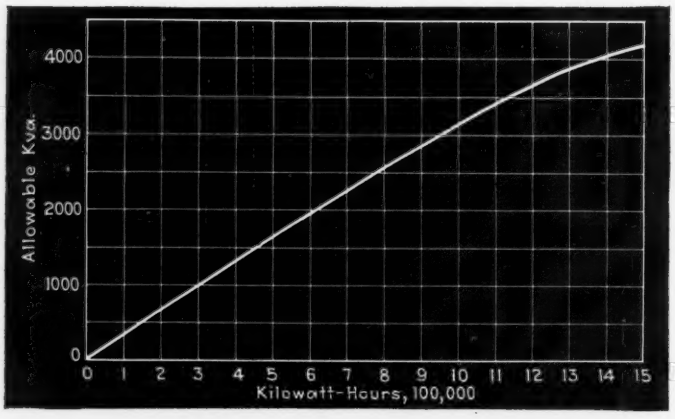
NO RED TAPE IN THIS SYSTEM OF

POWER-SERVICE CHARGES

By C. J. ZETLER, Jr.

Works Engineer
Westinghouse Electric & Mfg. Co.

Westinghouse factory departments pay for their actual use of electricity, and each carries its true share of the demand charge. Other services are charged at a fixed rate. A single "holding account" absorbs cost variation



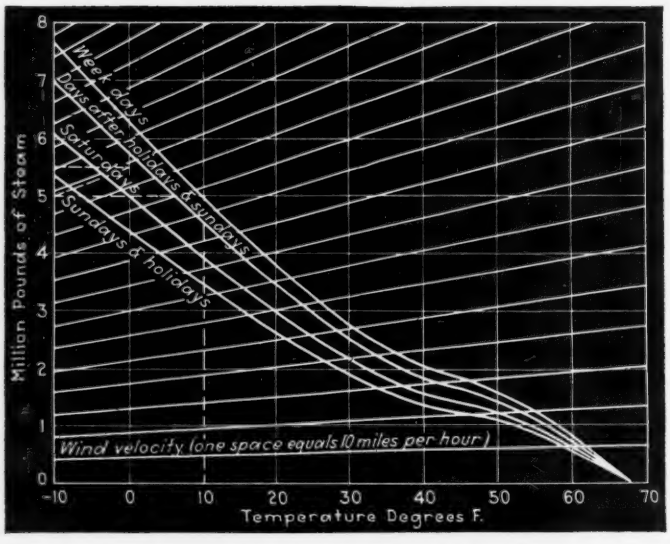


Fig. 1—This curve gives the allowable maximum demand. Fig. 2—Curves from which building heating steam is calculated (last column of this article explains method of use)

LARGE industrial plants are generally divided into departments, and these in turn are often subdivided, each division being a cost center under separate supervision. Where this is the case, it is essential that fairly accurate costs of the various services—power, steam, water, etc.—be available and so detailed that the heads of departments can analyze them.

For any method of obtaining departmental consumption of services to be of greatest benefit to the plant, the cost records must be kept in the power house. Accurate costs of labor, material, overhead, depreciation, insurance and taxes chargeable against the power plant should be kept—and in such manner that each type of service absorbs its correct charges.

In the Westinghouse plants at East Pittsburg and Trafford, a standard costing rate is maintained for each service supplied to the shops. These standard costs are so set up that they represent the average for each service and eliminate fluctuating rates. Any difference between the actual and the standard unit cost is credited or debited to a holding account. This system permits the departments to set up their manufacturing cost rates without danger of having them show excess profit or loss as a result of changes in rates for services.

The only item not handled in this manner is purchased power. A demand charge is paid on it, based on the highest kilovolt-ampere load. This power is charged to the departments on the basis of their average kilowatt-hour monthly consumption and kilovolt-ampere demands. The curve, in Fig. 1, was developed to take care of demand charges above those figured in the standard cost per kilowatt-hour. This allows each department a certain kilovolt-ampere demand, based on its kilowatt-hour consumption. Any excess demand is charged directly against the department causing it. Demand meters on department circuits and the power company circuit are synchronized, so that the departments causing excess peak demands are readily identified. This procedure is illustrated by the following example:

Department *A* had a monthly power consumption of 100,000 kw.-hr. with a demand of 600 kva. at the time the combined peak demand occurred. Department *B* consumed 800,000 kw.-hr. in the same month, with a demand of 2,500 kva. Department *C* had a kilo-

watt-hour consumption for the same month of 150,000 with a demand of 800 kva. A total of 1,050,000 kw.-hr. was purchased for the month, with a maximum 15-min. demand of 3,900 kva. From the curve it was found that the departments had kilovolt-ampere demand allowances based on their monthly power consumptions as given by the values in the table.

This excess charge of $430 is distributed 46.3 per cent to department *A* and 53.7 per cent to department *C*. Department *B* is given no credit, as it probably has had peaks in excess of 2,500 kva. during the month. By watching other department peaks each is able to take advantage of low peaks in others to hold its own demand charge down.

Where services to some departments are metered and to others unmetered, all meters are read monthly and the services billed to the metered departments, at a standard unit cost rate. After these are billed, there remains a part of the service to be accounted for. Instead of billing the departments with an estimated consumption for each of their unmetered items, they are grouped in a total cost and charged to each department. The division of the charge is based on a careful estimate of the consumption of each unmetered department.

This division is rechecked and revised once a year under ordinary conditions. Large variations, if they occur, can be taken care of, if necessary, but the percentage used in the allocation is not disturbed for minor adjustments. Distribution of the various services are made in the following manner:

Steam for power generation and shop processing—by meter and estimated consumption
Electricity—by meter and estimated consumption
Natural gas—by meter and estimated consumption
Water—by meter and estimated consumption
Hydraulic—estimated consumption
Vacuum, shop processing—based on cubical content of equipment to which service is supplied
Drinking water—based on number of employees in department
Heating and ventilating—based on square foot of floor space in department
Compressed air—by estimated consumption

Heating and ventilating is the space heating and ventilation of shops and does not include heating or ventilating of manufacturing processes as this is taken care of by the departments individually. Steam is supplied the heating system at two-pounds pressure from turbines running noncondensing or bleeding. When there is not sufficient electrical load to supply this steam from the turbines it is bled into the heating system through reducing valves.

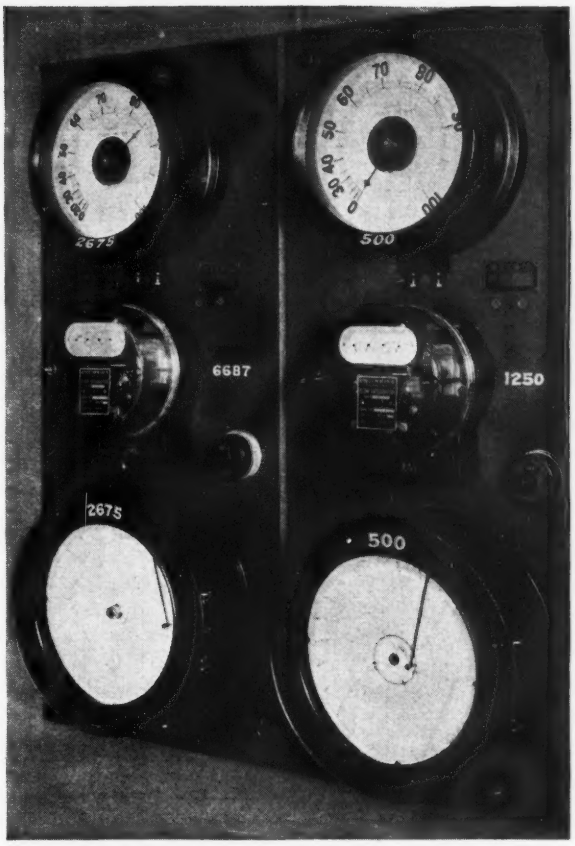


Fig. 3—Group of indicating, recording and integrating steam-flow meters on turbines

To keep a check on steam generation, a set of curves, Fig. 2, was plotted, from which can be estimated the steam requirements for heating and ventilating with given various outside temperatures and wind velocities.

On the curves the diagonal lines are for wind correction, and each space along a horizontal line represents a wind velocity of 10 miles per hour. Assume an outside temperature (on a week day) of 10 deg. above zero and a wind velocity of ten miles per hour. The dotted lines show the solution of the problem. Start at 10-deg. temperature and run vertically to the week-day curve, then horizontally to the steam values, where 5,000,000 lb. is obtained. To correct for wind velocity run parallel with the diagonal line for one division, representing 10 mi. per hour. Then run horizontally back to the steam line, where the answer "5,500,000 lb." is obtained.

KILOVOLT-AMPERE DEMAND ALLOWANCE BASED ON MONTHLY POWER CONSUMPTION

Department	Allowed Demand, Kva.	Actual Demand, Kva.	Excess Over Allowed Kva. Demand	Per Cent Excess Demand
A	350	600	250	46.3
B	2,600	2,500	—100	
C	510	800	290	53.7
Total	3,460	3,900	440	100.0

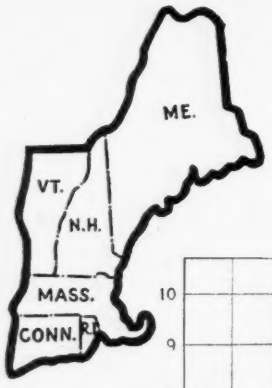
Total amount of bill for 3,900-kva. demand and 1,050,000 kw.-hr.	$9,440.00
Total amount of bill for 3,460 kva. demand and 1,050,000 kw.-hr.	9,010.00
Excess charge due to excess demand	$430.00

The men responsible for the operation of the heating system are paid a bonus for keeping the total under the estimate. In order that departments may be assured comfortable working conditions, the heating-system operators are penalized for trouble reports. The actual steam used has been kept within two per cent of that estimated during the past year. Similar curves have been plotted on requirements for other services, base on shop activity.

▼ ▼ ▼

***Power* Data Sheets**—On page 28 is presented the first of a series of *Power* Data Sheets. This sheet, and that to be printed in August, bring together in compact and convenient form fundamental conversion factors selected solely on the basis of their convenience to power engineers. They are laid out and computed without reference to previously existing tables. Many factors not elsewhere available are included for easy translation of short-time tests to a daily, monthly or yearly basis.

THE FUEL OIL SITUATION IN



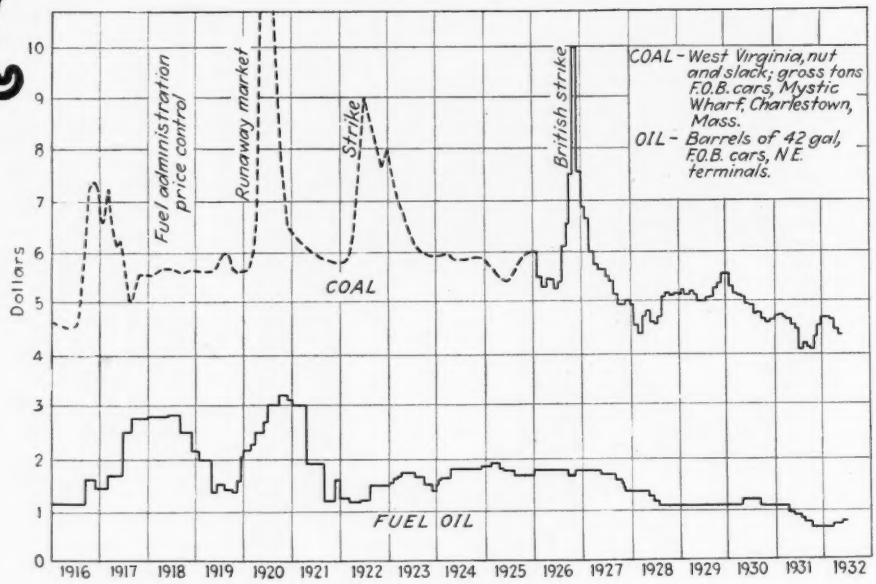


Fig. 1 — Monthly average coal and fuel oil prices from 1916 to 1932 show wide fluctuations. The probable trend of future prices should be considered when planning the installation of oil-burning or coal-burning equipment

THE important position held by fuel oil in New England industry is shown by the fact that in 1928 it represented about 23 per cent of the total industrial and utility fuel for this section of the country. The figures on which this percentage is based are 15,324,500 tons of coal[1] and 18,679,000 barrels of oil[2], equivalent to 4,670,000 tons of coal. It is probable that if figures were available for the last twelve months, they would show an even greater percentage of oil as a result of its recent low price and the number of plants which have been changed over to take advantage of it.

Table I shows the distribution of fuel oil among the six New England states for a 5-year period from 1926 to 1930. The figures in the table represent barrels of 42 gal. The last line of the table represents the percentage of fuel oil used in New England as compared to the whole United States. It may be rather surprising to those not familiar with the distribution of oil to know that the groups of states which use the larger quantities are as follows: Pacific Coast, 28 per cent; South Central, 23 per cent; Middle Atlantic 22 per cent. The percentages of the Pacific and Southern groups are greatly increased by the use of oil for locomotives. This table does not include the oil used for domestic heating, the volume of which now amounts to over 15,537,000 barrels for the entire country and is rapidly increasing.

Costs of Coal and Oil

Costs of fuel oil and coal from 1916 to the present are shown by the curves of Fig. 1. Oil prices[3] on which this curve is based are accurate over the whole period. Coal prices[4] are accurate from 1926 to the present. Before 1926 they are approximate, exact data not being available. Oil prices are per barrel of 42 gal. f.o.b. terminals, such as Chelsea, Portland or Providence. The coal prices are for West Virginia nut and slack, or stoker coal, for tons of 2,240 lb., f.o.b. Mystic Wharf, Charlestown, Mass. The actual cost of either fuel at any plant will, therefore be the value given on the curve plus the transportation from the terminal point.

The curves of Fig. 2 give a comparison of the costs of oil and coal on the basis of B.t.u. purchased for one cent. The curves of both Fig. 1 and Fig. 2 are worth careful examination to learn the history of the actual price situation between oil and coal.

Bunker *C* Fuel Oil

The following specifications for Bunker *C* fuel oil are quoted from the definition of the Federal Specifications Board for this grade of oil:

"It shall be a hydrocarbon oil free from grit, acid, and fibrous or other foreign matter likely to clog or injure the burner or valves.

Flash Point — Minimum by the Pensky-Martens closed cup tester, 150 deg. F.

Water and Sediment—Maximum 2.0 per cent.

Viscosity—Saybolt Furol at 122 deg. F., maximum 300 seconds."

The only difference between Bunker *C* and Bunker *B* or *A* fuel oils is the viscosity permitted at certain

[1]Bureau of Mines, "Coal in 1929"—the latest available figures.
[2]Bureau of Mines, "National Survey of Fuel Oil Distribution."
[3]Courtesy of Mexican Petroleum Corporation.
[4]Courtesy of The Commercial Bulletin.

NEW ENGLAND

By D. D. EAMES
Consulting Engineer
Boston, Mass.

When and why does it pay to use oil fuel for steam generation? Directed specifically to New England, Mr. Eames' article contains basic information of practical value to present and prospective users of fuel oil everywhere

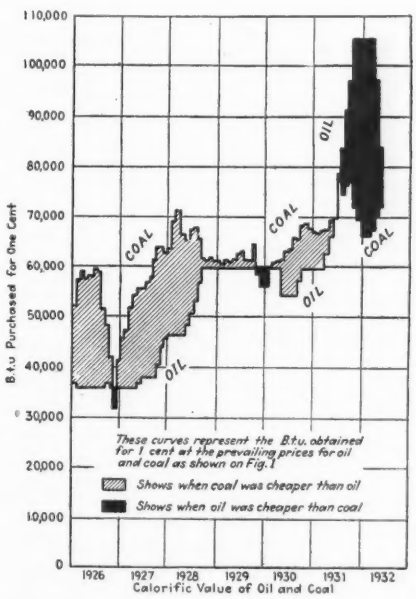


Fig. 2—Cost of heat energy in oil and coal. Curves show the heat units purchased by one cent at the prices shown on Fig. 1. Areas are shaded where coal was cheaper than oil and filled solid where oil was cheaper

temperatures, and the percentages of non-petroleum impurities allowed.

A new condition is now facing the users of fuel oil, some of whom have already felt its effects. Bunker *C* oil was formerly a product of low-pressure distillation and was fairly uniform in its essential characteristics. What is now sold as Bunker *C* oil seems to be anything of a combustible nature that is left after the refiners have taken all else of value out of it. The principal trouble from the new oil, containing refinery refuse or cracked residue, results from the floculent carbon which it contains. This precipitates out in storage tanks, heaters, and burners in sufficient quantities to cause serious trouble.

The new condition, therefore, results from the changes and improvements in refining processes which recover more gasoline from the crude oil but which leave a residue quite different from that which formerly resulted from the straight-run or low-pressure distillation processes. There seems to be little doubt that the quantity of cracked residue available will increase in the future and that the quantity of uncracked material will decrease. Fortunately this fuel has a high B.t.u. value which justifies the money and effort which may be required in clearing up the difficulties in handling it.

Present difficulties appear to be confined to those resulting from the deposits of carbon or other matter in form of a sludge. This carbon is present in various-sized particles, all extremely small, and they will deposit at varying rates depending on their size.

Heating the fuel permits the particles to settle out more rapidly. Because of this, the fuel should not be heated beyond the temperature required to reduce it to proper viscosity for burning. For cracked residue this temperature will, in general, be much lower than that required for the uncracked residues because of the difference in viscosity at any given temperature. Many instances of trouble have been reported from the cracked residue fuel and its tendency to deposit carbon in the strainers, heaters and atomizers.

In view of the greater difficulty of successfully handling and atomizing the newer oils, it is important that the engineer have an intelligent understanding of the properties of oil and the terms that are used in describing them.

The most common of all terms used in fuel-oil work is "gravity," which is a measure of the weight of the oil on an arbitrary scale, the most common of which is the well-known "Baumé" scale. It is used for liquids that are lighter than water. Water itself reads 10 deg. on this scale.

Degrees Baumé are determined by direct readings on the stem of a hydrometer immersed in the liquid. This is a simple and accurate measure for light oils, but for heavy viscous oil the very nature of the oil makes the process a slow one, subject to considerable error. It is worth noting that the Federal Specifications for fuel oil, as previously quoted, makes no mention of "gravity."

Table II, showing Baumé gravities and corresponding weights, is included for reference.

As has been stated, the practical controlling property in the use of fuel oil is "viscosity." There is no natural relationship between gravity and viscosity. Gravity affords no information whatever as to the correct temperature to which an oil must be heated either for good flowing or for good atomization. This is a function of viscosity.

Viscosity may be described as the resistance to internal movement, or the internal friction of a liquid. It is measured by noting the time required for a definite quantity of the liquid to pass through an orifice or a short tube under known conditions of temperature and head. The standard temperature for viscosity measurements is 122 deg. F. or 50 deg. C. There are several viscosimeters in use, such as the English Redwood Admiralty, the Engler and the Saybolt Universal, some

TABLE I — DISTRIBUTION OF FUEL OIL IN NEW ENGLAND
1926-1930

	1926	1927	1928	1929	1930
Maine	1,617,447	1,273,031	762,484	1,210,730	1,301,223
New Hampshire	175,590	153,594	111,815	160,980	223,274
Vermont	73,212	140,942	213,694	340,676	184,653
Massachusetts	12,080,091	11,975,634	11,239,933	12,520,413	11,847,729
Rhode Island	4,567,337	4,654,374	4,150,619	4,998,955	4,549,822
Connecticut	2,285,200	2,594,200	2,200,037	2,597,717	2,511,519
Total	20,797,877	20,791,775	18,678,582	21,829,471	20,618,220
per cent of total oil used in U. S.	5.58	5.45	4.70	5.31	5.

TABLE II — OIL WEIGHTS CORRESPONDING TO BAUMÉ SCALE

Baumé Scale	Specific Gravity at 60 Deg. F.	Lb. per U. S. Gal.
10	1.00	8.337
11	0.993	8.280
12	0.986	8.222
13	0.980	8.171
14	0.973	8.112
15	0.966	8.054
16	0.959	7.996
18	0.946	7.887
20	0.933	7.779
22	0.921	7.679
24	0.909	7.579
26	0.897	7.479
28	0.886	7.387
30	0.875	7.295
35	0.848	7.070
40	0.823	6.862

of which were developed primarily for lubricating oils.

The viscosity of fuel oils is often so high that it cannot be measured with these instruments. Consequently in 1920 the Saybolt Furol instrument was developed. It has become one of the accepted instruments for fuel oil viscosity measurements in America.

Research at the fuel oil testing plant, Philadelphia Navy Yard, has demonstrated that viscosity should be kept within the range of 75 to 150 sec. Saybolt Universal or 2 to 4 deg. Engler. The best over-all efficiencies are obtained at about 120 sec. Saybolt Universal, or 3.2 deg. Engler.

A third important property of oil, with particular reference to safety, is "flash point." The flash point of an oil is the temperature at which inflammable gas or vapor is given off. It is determined simply by heating the oil, and, as the temperature rises, testing it with a spark or flame until the vapor is distilled off and ignites, and the flash is noticed.

The point with regard to safety is this: Some oils may require heating above the flash point in order to reduce the viscosity to a proper point for atomization. Some slight unnoticed leak in the piping system or at a burner, may allow gas or vapor, under some circumstances, to collect in the fire room and lead to an explosion. The conditions under which this may happen are much more likely to occur in marine than in land work.

Equivalent Oil and Coal

On an exact heat equivalent, 5.15 bbl. of oil correspond to one gross ton of coal. For example, assume oil of 18,500 B.t.u. per lb., 8.1 lb. per gal., and 42 gal. per barrel. Similarly assume the calorific value of coal at 14,500 B.t.u. Then the number of barrels of oil equivalent to one ton of coal is:

$$\frac{14{,}500 \times 2{,}240}{18{,}500 \times 8.1 \times 42} = 5.15 \text{ bbl.}$$

This does not, however, represent the true equivalent in usual cases. The efficiencies of the particular coal plant and oil plant which are being compared always enter in. For example, if a certain coal-burning plant has an actual efficiency of 68 per cent and a change to fuel oil is estimated to result in an efficiency of 78 per cent, how much oil will be equivalent to one ton of coal? The equation then becomes,

$$\frac{14{,}500 \times 2{,}240 \times 0.68}{18{,}500 \times 8.1 \times 42 \times 0.78} = 4.50 \text{ bbl.}$$

The higher the efficiency of the coal plant the more oil it takes to equal a ton of coal. Table III gives a few equivalent values of oil and coal for assumed efficiencies.

TABLE III — EQUIVALENTS FOR ASSUMED EFFICIENCIES

Efficiency of Plants — Coal	Efficiency of Plants — Oil	Bbl. Oil Equivalent to One Gross Ton Coal
60	76	4.07
65	77	4.35
70	78	4.63
75	79	4.90
80	80	5.15

A fair figure to use for ordinary computations is 4½ bbl. of oil equivalent to one gross ton of coal and 4 bbl. to one net ton. Plant engineers should be careful to check any claims of more favorable equivalents against their actual conditions of effiicency and heat value.

A coal burning plant of poor or moderate efficiency can always be substantially improved by a change to fuel oil. The combustion efficiency will be raised, the labor and maintenance perhaps reduced, and a good saving made, provided the relative prices of oil and coal stay right. The recent unprecedented low price of fuel oil has been the deciding factor in many cases.

The underlying idea in practically all of these changes is, of course, the monetary saving. In arriving at the determination as to whether the change to oil should actually be made, careful consideration should be given to the following question: *Will the savings from oil, when correctly and conservatively estimated, within the duration of the oil contract which can be obtained, pay for the first change from coal to oil and also pay for changing back again to coal, in case a favorable new oil contract cannot then be secured?* If this question cannot be favorably answered, the mill, in going ahead with oil, is incurring the risk of an unprofitable expenditure when the oil contract expires.

When making these estimates the additional fact should not be lost sight of, that similar plant improvements and fuel savings may be obtained by the installation of modern coal burning equipment as well as by oil equipment. The question of saving money by improving the efficiency of an old plant thus resolves itself into a comparison of first costs, operating costs and probable life of modern oil-burning apparatus as against modern coal-burning apparatus.

Oil fuel certainly has a large and proper place in industrial work. There are some uses to which it is preeminently suited and where its use at a premium is, in many cases, fully justified. Such places are food industries, some textile and paper mills where dust and cinders cause loss of goods, laundries, city building heating and marine uses. It is the writer's candid opinion, however, that coal is the basic fuel for this section of the country[6], and that the use of fuel oil will, in the long run, result in a higher cost of fuel.

The ideal arrangement is for a plant to be equipped to use either oil or coal and thus take advantage of favorable prices for either fuel. This of course requires double equipment, half of which is idle all of the time, with the additional difficulty, in many instances, that the furnaces are not adapted to the use of both fuels.

[6] "Recent Boiler Practice in New England," *Power*, Nov. 11, 1930.

PRESSURE DROP IN STEAM PIPES

By JULIUS HULMAN

Terre Haute, Ind.

EVERY plant designer is at some time confronted with the problem of calculating the pressure drop in steam pipes or of determining the smallest pipe size that can be used without producing an objectional loss of pressure. Of the many formulas used to determine pressure drop in steam pipes, the three most important are the Carpenter, Rational and Fritszche. All involve higher exponents which make their solutions tedious work, especially when a number of calculations must be made. By using the chart below these arduous calculations, together with the errors that so easily slip into work of this kind, can be avoided.

The chart is based on the Fritszche formula, which is: $P = \frac{0.8M^{1.85}LV}{D^5}$ where: P = pressure drop, lb. per sq. in.; M = pounds of steam flowing per sec.; L = equivalent length of pipe in feet; V = specific volume, cu.ft. per lb.; D = internal diameter of pipe, in.

The group of seven vertical lines to the right of the D scale aid in finding the nominal pipe size after the internal diameter is found or the internal diameter in cases where the pipe size is known. Always refer a point on these lines to the D scale.

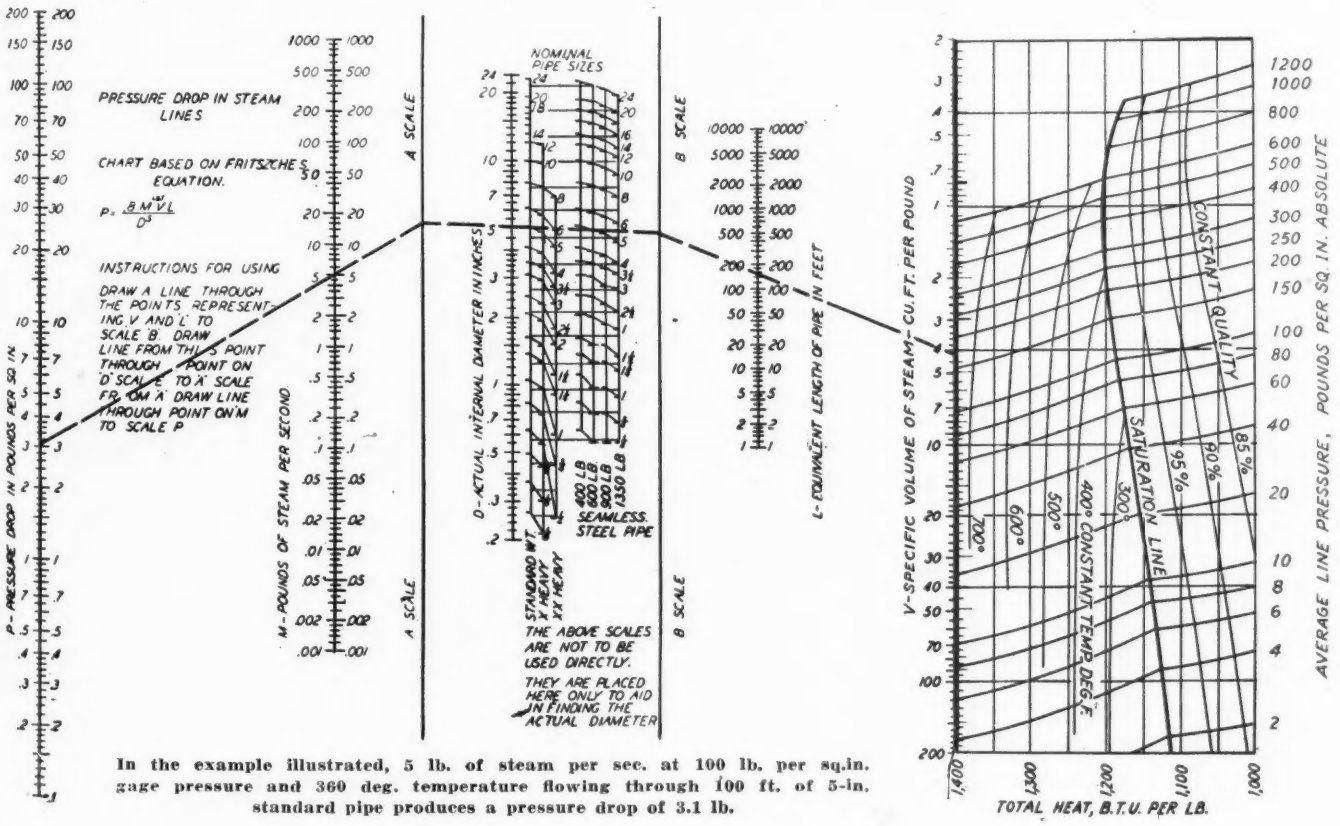
The chart to the right of the V scale has been provided so that the specific volume of steam may be found from known pressures and temperatures without having to refer to steam tables, and has been adapted from a chart in the "Piping Hand Book." As in the pipe size chart points on this chart should be referred to the V scale of specific volume.

The chart will give satisfactory results for pressure drops up to 35 per cent of the initial steam pressure, but above this a different equation should be employed. For pressure drops exceeding 10 to 15 per cent of the initial pressure the average specific volume of the steam should be used. In fact, it is best to use the average specific volume for V in any case, but this point is usually neglected for pressure drops below 10 per cent.

Example: What size pipe should be used to obtain a final pressure of 75 lb. per sq.in. abs. when 10 lb. per sec. of initially dry steam at 100 lb. per sq.in. abs. pressure flows through a 200-ft. length of pipe?

The first step in this problem is to find the average specific volume. The initial specific volume can be found from the chart at the right. As the steam flows through the pipe there is some heat loss due to radiation and convection. However, this loss is not very great per pound of steam, even with ordinary insulation. Assuming no heat loss the final volume may be determined as if the steam were at 75-lb. pressure and with a heat content equal to the original heat content. Proceeding in this manner, the chart at the right of the V scale gives initial $V = 4.4$, final $V = 5.9$, average $V = 5.2$.

Using this value, draw a line from the V scale through 200 ft. on the L scale to intersect the dummy scale B. Draw a line from the point on the P scale representing 25-lb. pressure drop through 10 lb. per sec. on the M scale to intersect the dummy scale A. Connect the points on the dummy scales A and B, and the intersection on the D scale gives an inside diameter of 4.6 in. Therefore, a 4- or 5-in. standard pipe would be used.


P - PRESSURE DROP IN POUNDS PER SQ IN.
PRESSURE DROP IN STEAM LINES
CHART BASED ON FRITSZCHE'S EQUATION.
INSTRUCTIONS FOR USING
DRAW A LINE THROUGH THE POINTS REPRESENTING V AND L TO SCALE 'B'. DRAW LINE FROM THIS POINT THROUGH POINT ON 'D' SCALE TO 'A' SCALE FROM 'A' DRAW LINE THROUGH POINT ON M TO SCALE P
M - POUNDS OF STEAM PER SECOND
A SCALE
D - ACTUAL INTERNAL DIAMETER IN INCHES
NOMINAL PIPE SIZES
STANDARD WT.
X HEAVY
XX HEAVY
400 LB
600 LB
900 LB
1350 LB
SEAMLESS STEEL PIPE
THE ABOVE SCALES ARE NOT TO BE USED DIRECTLY.
THEY ARE PLACED HERE ONLY TO AID IN FINDING THE ACTUAL DIAMETER
B SCALE
L - EQUIVALENT LENGTH OF PIPE IN FEET
V - SPECIFIC VOLUME OF STEAM - CU. FT. PER POUND
CONSTANT QUALITY
85%
90%
95%
SATURATION LINE
400° CONSTANT TEMP. DEG. F.
300°
500°
600°
700°
AVERAGE LINE PRESSURE, POUNDS PER SQ. IN. ABSOLUTE
TOTAL HEAT, B.T.U. PER LB.

In the example illustrated, 5 lb. of steam per sec. at 100 lb. per sq.in. gage pressure and 360 deg. temperature flowing through 100 ft. of 5-in. standard pipe produces a pressure drop of 3.1 lb.

NO POWER PLANT IN McGRAW-HILL BUILDING

By CHARLES P. WOOD*

Common-sense power production and utilization demands consideration of each individual problem, for each is affected by circumstances and conditions so peculiar to itself as to permit the application of no infallible formula excepting the general rule that power shall be made when it should be made and bought when it should be bought.

With the express purpose of stimulating people to think of power in terms of its most economical production, *Power* is publishing a number of specific analyses. Most of those already published have indicated greater economies by making power than by purchasing it. In this article it is apparent that the economies lie in the purchase of power and steam rather than the making of them

▼

THE McGraw-Hill building, which was completed in November, 1931, is located on 42d Street, New York City, and extends through to 41st Street. The building is 33 stories high and has an approximate volume of 8,057,000 cu.ft. Other features of the building were described by *Power* in the article[1] on the heating system and elevators. The building contains no boilers or engines, both power and steam being purchased.

The decision to purchase electricity and steam was based on studies by Lockwood Greene Engineers, Inc., who were employed as consultants when the building was being planned in 1930.

Several different power plant arrangements were considered for the building, but in all of these sufficient spare capacity was planned so that the plant would operate reliably without purchasing standby service. The costs indicated by the comparison showed that purchased power and steam would cost substantially the same as these services supplied from a plant in the building.

With no economic advantages indicated in favor of the building power plant, the decision was made against installation, as purchased power and steam would fulfill all other requirements. Moreover, a heating or power plant in the basement would complicate the architectural design of the building, not only because of additional basement space required for the plant (as well as access for delivery of oil or coal) but also because a smokestack and an atmospheric steam relief pipe, both extending above the roof, would interfere with the most convenient arrangement of each floor.

The building is devoted to office space, and a publishing plant, the latter involving a printing press load of 2,900 kw. Retail stores on the ground floor require basement space on one side of the building. The central portion of the building in the basement is taken up by elevators, leaving only enough basement for the normal requirements of general service equipment and paper storage space. Consequently, a sub-basement would have had to be provided for the installation of a heating plant or power plant. The cost of providing such a sub-basement, allowing for rock excavation, would have been about $40,000 for the heating plant and $60,000 for the power plant.

The connected electrical load in the building was estimated as follows: lighting 1,630 kw., power 2,222 kw., which, with an allowance of 720 kw. for future power load, makes a total of 4,572 kw. With this connected load a power plant having capacity to provide for a peak load of 2,000 kw. would be required. It was expected that for ten hours a day the average load would be about 1,000 kw. Thus for a year of 300 days' operation the total plant output would be 3,000,000 kw.-hr., or the equivalent to 250,000 kw.-hr. a month.

Based on these estimated loads, the New York Edison Company offered the following power rates.

First 300 kw. of demand (maximum 30-min. average) at $2.50 per kw.

Balance of demand at $1.50 per kw.

First 12,500 kw.-hr. of energy at $0.025 per kw.-hr.

Next 50,000 kw.-hr. $0.02 per kw.-hr.

Next 50,000 kw.-hr. $0.015 per kw.-hr.

Balance, $0.01 per kw.-hr.

For the purpose of estimating the cost of purchased power, at the rate of 250,000 kw.-hr. a month, the maximum demand was assumed to be 1,260 kw. This is the sustained demand over a period of 30 min. and is considerably lower than the peak load which would have to be carried by a power plant serving the building. On this basis, at the above rate, the cost of 250,000 kw.-hr. per month would be:

Demand charge for 1,260 kw	$2,190
Energy charge for 250,000 kw.-hr	3,437.50
Total	$5,627.50
Cost per kw.-hr.	$0.0225

The McGraw-Hill Building has an unusually large amount of glass-window area, and in addition is exposed

*Member, A.I.E.E.; Industrial Engineer Lockwood Greene Engineers, Inc.

[1]*Power*, Nov. 3, 1931.

Looking east. McGraw-Hill Building in left foreground, Empire State Building at upper right

to the elements on all four sides. For this reason a somewhat liberal allowance for heating-system steam was made. Plans called for the installation of 80,995 sq.ft. of equivalent direct radiation. This amount of radiation, during severe weather, calls for a steam consumption of 20,249 lb. of steam an hour. With the building fully occupied, 41,125,000 lb. of steam per year would be required for building heating.

Based on the use of 10 lb. of hot water per day per 1,000 cu.ft. of building volume, which is comparable with the use of hot water in other office buildings, there would be required about 80,000 lb. of hot water per day. Heating this water would require approximately 10,000 lb. of steam. On this basis, the monthly use of steam for 25 days a month would be 250,000 lb., or 3,000,000 lb. per year. The maximum demand for hot water would be about 8,000 lb. an hour, which would require approximately 1,000 lb. of steam an hour.

The above estimate gives a total of 44,125,000 lb.[2] of steam as the amount required per year for building and hot-water heating. The estimated maximum demand, including 40 per cent additional steam for warming up the heating system, is 29,400 lb. of steam per hour.

At the rates offered by the New York Steam Corporation, this amount of steam would cost $37,765 a year. To this must be added 6 per cent interest on $30,000, the cost of a steam connection paid for by the building company, making a total cost of $39,565, or 90 cents per 1,000 pounds.

[2]The estimated steam requirements for building heating appears too high. Data published by the National District Heating Association indicates that with the type of heating system installed the steam consumption might be expected to be about 60 lb. per 1,000 sq.ft. of radiation per degree day. The number of degree days for New York City is about 5,500, so that with 80,995 sq.ft. of radiation the yearly steam consumption on this basis would be about 30,000,000 lb. This, of course, does not affect the size of boiler plant installed, as the peak load will remain the same. This smaller steam use would raise the average cost of purchased steam to about 92c. per 1,000 lb. The cost of steam from a boiler plant in the building also increases to about $1.00 per 1,000 lb. Thus the estimate used slightly favors a boiler installation.—EDITOR.

Several plant arrangements for supplying heat and power were considered. These comprise the following:

1. Boiler plant for heating, power purchased.
2. Complete steam boiler plant and non-condensing turbine furnishing power and steam for heating.
3. A combined steam and diesel-engine plant furnishing both power and heat.
4. A diesel and steam-engine plant generating power from purchased steam, using exhaust for heating.

In making the cost estimates for these four types of plants items of operating costs were limited to those over and above what would apply to operation with purchased steam and power. The value of space throughout the building occupied by the stack was charged to operation at $1 per sq.ft. of floor space. This is a low rate for this type of building, especially as there would be an additional loss caused by interference with the most convenient arrangement of each floor.

Oil at 4c. a gallon was considered the most economical and satisfactory fuel. There should be provision, however, for changing over to coal in case the price of oil were to increase out of proportion to the price of coal. In this respect, the estimated cost of the boiler-room construction and boilers may be too low, because allowance should be made for coal storage space and stoker equipment. This allowance has been omitted in order to give the steam plant the benefit of the doubt.

In the following tabulation of fixed charges maintenance of equipment is included in place of a repair item in the estimates of operating costs.

	Per Cent	
	Building	Equipment
Interest	6	6
Depreciation	2	5
Insurance and taxes	3	3
Maintenance	..	1
	11	15

Average boiler efficiency in all cases was assumed at 70 per cent, somewhat below what might be possible, but considered a fair figure to allow for periods of light loads

and for the normal waste of fuel. The estimates which follow are condensed for clarity.

FIRST COST OF HEATING PLANT

Boilers and settings, three 2,500-sq.ft.	$26,250
Oil burning equipment and storage	10,000
Smoke breeching	1,500
Stack and masonry enclosure	15,000
Piping	5,000
Summer boiler	1,500
Construction of boiler room	35,000
Architects' and engineers' fee, 6 per cent	5,650
	$99,900

OPERATING COST OF HEATING PLANT

Fuel, 440,000 gal. at $0.04 per gal.	$17,600
Power for oil burners	500
Labor:	
3 shifts at $35 per week, 30 weeks	3,150
1 shift at $35 per week, 22 weeks	770
Liability insurance and supplies	2,000
Fixed charges:	
Equipment at 15 per cent	9,410
Building at 11 per cent	4,080
Loss of revenue due to stack space	1,500
	$39,010
Cost per 1,000 lb. of steam	$0.884

Three boilers at 2,500-sq.ft. heating surface each would be required in the boiler plant to serve the building with its steam needs. This allows for one spare, with two boilers in operation at 175 per cent rating. In calculating the fuel consumption, oil of 149,000 B.t.u. per gal, was considered, which with a boiler efficiency of 70 per cent gives an evaporation of 100 lb. of water per gal. of oil. The chief engineer's salary has not been included in the cost of operation, since it was assumed that he would be required in the building anyway.

Power Plant With Non-Condensing Turbine

The estimate of the first cost and the operating cost of a power plant using non-condensing steam turbines was simplified, because the average load assumed for power requires about 15 per cent more steam than the average estimated for heating during the eight months of the year. Before designing a plant, it would be necessary to examine the relation between heating load and power load more closely and to provide for heating steam direct from the boiler, if necessary, during periods of low power loads. Such a contingency would reduce the over-all efficiency of the plant and increase the cost of power and steam above that in this estimate.

To provide for the estimated peak load of 2,000 kw., a power plant containing three 1,000-kw. units was considered necessary. Units of this size operating with steam at an initial pressure[3] of 200 lb. with 100 deg. of superheat, and exhausting against a 5-lb. back pressure, would have a steam rate of approximately 30 lb. per kw.-hr. To provide steam for the turbines and building heating, three boiler units, each containing 6,000 sq.ft. of heating surface, would be required. In estimating the operating cost of this plant it was assumed that 100 lb. of steam would be evaporated per gallon of oil containing 145,000 B.t.u. per gallon.

The tabulation of first cost for this power plant has been materially condensed, and various items that are omitted, such as a small unit for night service, a summer boiler and pumps, may be assumed to be lumped with the larger items or included in miscellaneous.

Since the cost of heating the building from a boiler plant in the building would be $39,010, this sum has been deducted from the total cost of operating the power plant before computing the cost of power. The cost of power

[3]A plant designed to operate with a steam pressure of 350 lb. and 200 deg. superheat would probably produce power at the rate of 2.7 mills per kw.hr. lower fuel consumption than the plant studied. However, the engineers felt it inadvisable to install high-pressure equipment in a building where it might not receive the quality of supervision required.

FIRST COST OF STEAM POWER PLANT

Boilers, three, 6,000-sq.ft. each, installed with superheater and setting	$99,000
Oil burning equipment and oil storage	20,000
Stack, instruments and miscellaneous	25,000
Piping and boiler auxiliaries	50,000
Turbine-generators, three, 1,000-kw., non-condensing, with foundations	90,000
Switchboard and wiring, additional for generating plant	6,000
Building boiler and turbine room in sub-basement	60,000
Architects' and engineers' fee	21,000
	$371,000

OPERATING COST OF STEAM POWER PLANT

Fuel, 900,000 gal. oil at 4c. a gal.	$36,000
Labor:	
Chief engineer, extra for power plant	2,400
3 shifts, 2 men each	10,600
Fixed charges:	
Building at 11 per cent	6,996
Equipment at 15 per cent	46,110
Liability insurance and supplies	5,000
Stack space at $1.00 per sq.ft.	1,500
	$108,096
Credit cost of steam for heating	39,010
Cost of 3,000,000 kw.-hr.	68,996
Cost per kw.-hr.	0.0229

arrived at in this manner, as indicated in the tabulation, is 2.29c. per kw., which is only 0.4 mills more than power would cost if purchased.

Combined Steam and Diesel Plant

The combined steam engine and diesel-engine plant was considered on the theory that the steam plant would be shut down at the end of the heating season and the load carried on the more economical diesel engine during the five remaining months, when the only steam required for building service is that used for heating hot water. The diesel engine would also be used during periods of light steam demands to carry part of the load.

In such a plant the boiler installation would have to be large enough to furnish the demand for steam used in building and hot-water heating, with a spare unit to take care of emergencies. The turbines should have sufficient capacity to utilize this amount of steam. As economy depends on shutting down the steam plant during the off-heating season, the diesel engine would have to have capacity sufficient to provide for the building power load. Thus there would be required a 2,000-kw. turbine installation as well as a 2,000-kw. diesel-engine installation. Another combination that might be considered would be a 1,000-kw. turbine with three 1,000-kw. diesel engines. In either case the net increase in total generating capacity is 1,000 kw. more than the straight steam plant previously considered. The cost of this equipment would be so much higher that its fixed charges would offset the decreased operating cost due to improved efficiency. In addition the space requirement in the basement would also be increased. Because of these considerations this power plant arrangement was not studied in detail.

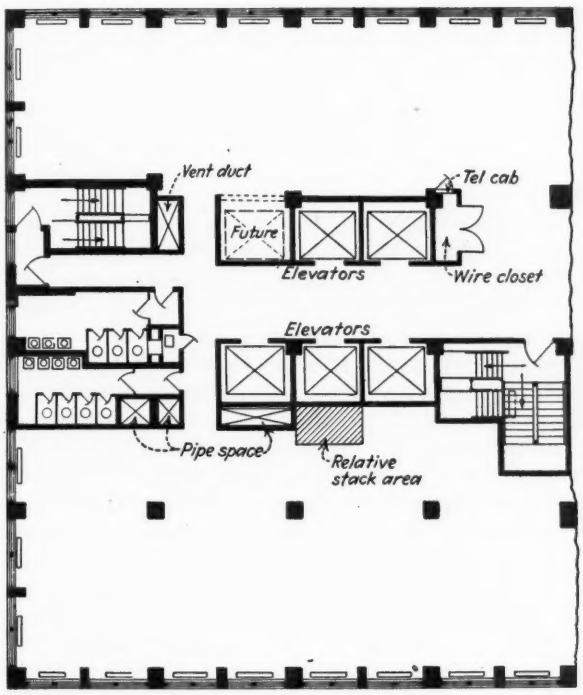
Steam and Diesel Engines With Purchased Steam

The fourth power-plant arrangement considered was one that provided for a steam-engine plant generating power from purchased steam and utilizing the exhaust for building and hot water heating, together with a diesel-engine installation to provide power during the summer when the steam consumption is very small.

The use of purchased steam at approximately 125-lb. pressure without superheat makes it desirable to substitute a low-speed engine for a high-speed turbine. For this plant it was considered that 1,500 kw. in steam-engine capacity and 1,500 kw. in diesel-engine capacity would satisfy the plant requirements, the exact size of the units to be installed being a subject for more detailed study. A small steam engine would be required for utilizing the minimum steam consumption during the off-

heating season and during this time would supplement the load carried on the diesel engines. The larger steam engine unit could serve as a spare during diesel operations, and the diesel-engine unit would serve as a spare for the heating plant at other times. Such an installation would be very flexible. The use of purchased steam, making the full steam capacity available at all times without the standby losses that would be involved with a boiler plant, reduces the total required installed capacity to about 1,500 kw. in both diesel and steam engines respectively.

By guaranteeing a minimum steam consumption of 250,000 lb. per month for twelve months, the lowest rate for purchased steam is obtained. It should be noted that this steam consumption coincides with the estimated



Section of a tower floor plan, showing arrangement of service facilities and relative area that would have been required by a power plant stack

steam demand for heating hot water which applies during the summer months. The steam rates that apply are:

Designated monthly demand

For the first 250,000 lb. of designated monthly demand, $1 per 1,000 lb.

For the balance of the designated monthly demand, 60 cents per 1,000 lb.

Excess over designated monthly demand

For the first 250,000 lb. supplied in each monthly period, $1.25 per 1,000 lb.

For the excess over 250,000 lb. supplied in each monthly period, 80 cents per 1,000 lb.

To the above rates was added a correction for coal costs which at the time of the study was 3c. per 1,000 pounds.

The fuel oil consumption for the diesel engine was taken at 0.1 gal. of oil per kw.-hr. The steam engine was assumed to have a steam rate of 35 lb. per kw.-hr. when operating with dry saturated steam at 125 lb. pressure and exhausting against 5-lb. pressure.

The estimated installation cost for a power plant such as that indicated is as follows:

FIRST COST OF STEAM AND DIESEL ENGINE PLANT USING PURCHASED STEAM

Steam engines, direct-connected, generator 1,500-kw. with foundations	$120,000
Diesel engines, direct-connected generator 1,500-kw. with foundations, auxiliaries and exhaust	187,500
Switchboard	6,000
Piping and oil storage	15,000
Building engine room	40,000
Architects and engineers fee	22,000
Total	$390,500

To determine the amount of power generated by the steam engine and diesel engine and also to determine the cost of purchased steam, the steam consumption and the kilowatt hours generated for each month are tabulated in Tables I and II.

TABLE I — STEAM REQUIRED FOR BUILDING SERVICE

Month	Total Steam Purchased, Lb.	Pound at $1.03 per 1,000 Lb.	Pound at $0.63 per 1,000 Lb.	Pound at $1.28 per 1,000 Lb.	Pound at $0.83 per 1,000 Lb.
January	8,575,000	250,000	.....	250,000	8,075,000
February	8,350,000	250,000	.....	250,000	7,850,000
March	6,300,000	250,000	.....	250,000	5,800,000
April	3,100,000	250,000	.....	250,000	2,600,000
May	1,000,000	250,000	.....	250,000	500,000
June	250,000	250,000	.....	.....	.....
July	250,000	250,000	.....	.....	.....
August	250,000	250,000	.....	.....	.....
September	250,000	250,000	.....	.....	.....
October	3,100,000	250,000	.....	250,000	2,600,000
November	4,700,000	250,000	.....	250,000	4,200,000
December	8,000,000	250,000	.....	250,000	7,500,000
Total	44,125,000	3,000,000	.....	2,000,000	39,125,000

TABLE II — POWER GENERATED BY STEAM AND DIESEL ENGINES

Month	Steam Engine Kw.-Hr.	Diesel Engine Kw.-Hr.	Total Kw.-Hr.
January	250,000	.....	250,000
February	250,000	.....	250,000
March	175,000	75,000	250,000
April	90,000	160,000	250,000
May	28,000	222,000	250,000
June	7,000	243,000	250,000
July	7,000	243,000	250,000
August	7,000	243,000	250,000
September	7,000	243,000	250,000
October	90,000	160,000	250,000
November	135,000	115,000	250,000
December	220,000	30,000	250,000
Total	1,266,000	1,734,000	3,000,000

It should be noted that the estimates of running expense shown below include only items that do not apply to purchased steam and power. As shown by this tabulation the cost of power is 4.7 mills per kilowatt greater than in the case of a steam turbine power plant and 5.1 mills per kilowatt greater than purchased power.

OPERATING COST STEAM AND DIESEL PLANT WITH PURCHASED STEAM

Cost of Purchased Steam	
3,000,000 lb. at $1.03 per 1,000 lb.	$3,090
1,750,000 lb. at $1.28 per 1,000 lb.	2,560
39,375,000 lb. at $0.83 per 1,000 lb.	32,473
Interest on $30,000 at 6 per cent	1,800
	$39,923
Diesel engine fuel, 173,400 gal. at 5c. per gal.	$8,670
Chief engineer	2,400
Labor, 3 shifts, 2 men each	10,000
Fixed charges:	
Building, 11 per cent	4,660
Equipment 15 per cent	52,200
Liability insurance and supplies	4,000
Total	$121,853
Credit cost of steam for heating	39,010
Cost of 3,000,000 kw.-hr.	$82,843
Cost per kw.-hr.	.0276

The cost of heating the building, as shown by the above estimates, is approximately the same with purchased heat as it would be with an independent plant.

Likewise, cost of power, after crediting heating cost to operating expenses, is slightly lower when purchased than when generated in an independent plant, running at the estimated average load of 1,000 kw. Thus in this case it appears that the investment required for the installation of generating equipment for heat and power would not be justified.

EVERY GOOD BOILER

must be at least

FIFTY PER CENT FURNACE

By H. G. LYKKEN

Chief Engineer, The Strong-Scott Mfg. Co.

IN THE good old days, boilers were designed primarily from the standpoint of the civil engineer—as vessels to withstand a given pressure.

It was appreciated, of course, that the function of the boiler was to generate steam and that in so doing it had to absorb heat. The theory of design, however, was limited entirely to heat absorption by convection and no thought was given to radiant heat absorption or to the relationship of the boiler to furnace conditions and temperatures.

There was considerable concern over the method of baffling, gas flow and circulation, but at best the boiler was little more than a heat-absorbing gas passage.

A boiler with 600 sq.ft. of surface per foot of furnace width was offered alongside of boilers with 300 sq.ft. per foot of furnace width—100 per cent variation in tube exposure. There was as much or more variation in exposed tube length. Even when the boiler initially had considerable exposable tube area, one-half to two-thirds of it would be cut off by a bridge wall.

When operation at 8 per cent to 9 per cent CO_2 was considered satisfactory, it made little difference, of course, as the "temperature of generation"[1] would be about 2,000 to 2,250 deg. F. Little or no radiant heat absorption was necessary under such conditions. There was little or no wall deterioration and no slagging with most coals.

Present-day demands for efficiency, however, require operation with 14 or 15 per cent CO_2. This gives a "temperature of generation" of about 3,500 deg. F. This changes the picture completely and makes the old conception of boilers as impractical as a wooden axle in an automobile. The demand for increased ratings and necessarily greater heat input aggravates the situation.

To obtain maximum efficiency from the convection surfaces, the gases should not be in excess of 2,000 deg. as they enter the first pass of the boiler. With many low-fusion-ash coals, they should be even less, to obviate the possibility of slagging over. It is equally necessary that the walls and floor of the furnace be not hotter than this temperature if the ash fuses at 2,000 deg. or less.

It therefore becomes apparent that, if we generate the gas at a temperature of 3,500 deg. F. and if it must not be in excess of 2,000 deg. F. as it leaves the furnace, there must be heat removal equivalent to at least 1,500 deg. temperature change while the gases are yet in the furnace. This temperature difference represents about 43 per cent of the heat in the gases,[2] above zero, or about 50 per cent of the heat available in an ordinary boiler installation whose exit flue-gas temperature is around 500 deg. F.

The necessary and inescapable conclusion is that, with operation at 14 per cent CO_2, half of the heat absorbable by the boiler must be absorbed before the gases leave the furnace. There is no alternative. It makes no difference how the coal is burned—whether in the pulverized form or on a grate with any type of stoker. The boiler becomes something more than a means of absorbing heat by convection. At least one-half of its function must be directed toward absorbing the heat directly by radiation.

If it is desired, for example, to generate 90,000 lb. of steam on a "from and at 212" basis, and we have a set-up that is expected to operate at 80 per cent overall efficiency, we will have a total heat input in the furnace of $90{,}000 \times \frac{970}{0.80}$, which equals 109,000,000 B.t.u.

If we intend to operate with 14 per cent CO_2, it is necessary, as already indicated, that 43 per cent of this heat, or 46,900,000 B.t.u., be absorbed in the furnace. If the operation is to be in excess of 14 per cent CO_2, or if the temperature must be reduced below 2,000 deg., the absorption in the furnace must be even more.

It is just as necessary a function of the boiler to absorb the heat that must be absorbed in the furnace as it is for the boiler to absorb the maximum heat from the gases after they enter its passes. The function of the boiler necessarily begins, therefore, at any and all points of the furnace where heat is liberated, not merely where the gases first enter the tubes.

Not only must there be sufficient radiant-absorbing surface in the boiler to take care of the 43 per cent or more of the total heat input, but that surface must be

[1]The term "temperature of generation," as used by Mr. Lykken, denotes the final temperature that would be obtained in an all-refractory insulated furnace with no tube exposure. It bears no relation to any actual temperature existing in any part of a boiler furnace.

[2]Again referring to the "temperature of generation."

properly placed. It is not only essential that the gases be reduced to the desired temperature at the first pass, but this temperature must be kept below the slagging limit in all parts of the furnace.

The amount of heat that a given surface exposed in a furnace will absorb can be calculated. This varies, however, with its location in the furnace, with fuel bed or flame temperature and other factors. In spite of such variation, there is no difficulty in determining it for any given condition. Further, it is essential that it be determined even in the smallest installation.

This does not mean that such consideration calls for water-walls in all cases, or even in the majority of cases, but it does mean that it will often determine the proper width of the boiler, its type or length of tube exposure.

The radiant heat absorption capacity may vary more than 200 per cent in the so-called standard-type boilers offered on any given job, with a difference between success and failure of the installation as a reward for careful selection.

The time has passed when boilers should be bought on the basis of the obsolete 10 sq.ft. per meaningless rated horsepower. They must be selected on the basis of capacity to absorb a given amount of the total heat input by radiation, as well as to absorb as much as possible of the remaining heat in the gases.

It is the boiler, its radiant-heat-absorbing surface and that surface's placement which limits furnace conditions including temperature, deterioration due to localized excess heat, slagging and, of course, possible efficiency.

The time has come when boiler specifications should place on the boiler manufacturer every responsibility for heat absorption *when, where* and *as* generated, based on a desired total heat input, desired efficiency, method of firing and temperature limitation at any and all points of the furnace, with the fuel to be used, governing. In installations where water-walls are necessary, the arrangement will, of course, vary with the method of firing. The boiler for installations of any consequence has ceased to be a standardized arrangement of tubes and drums. It must be built around a given condition of flame or fuel bed.

The boiler is more than half the furnace, even in the case of the simplest type. Its width and length of tube exposure determine what can be done in the furnace and what happens to the furnace. If any portion of the furnace is excessively hot, with resulting damage and difficulties of operation, it is due to deficiencies in the boiler or its method of setting to meet the requirements. It is not absorbing the heat generated where it should be absorbed.

Absorption of the heat *"where, when* and *as* generated" is no idle phrase. There is no alternative. The responsibility rests on the boiler. There is no way to fire a boiler with the minimum excess air demanded by present-day efficiency without excessive furnace temperatures, unless the boiler is designed to do half its work by radiant heat absorption.

Unfortunately in many installations these considerations are largely overlooked, and altogether too many mere arrangements of tubes and drums are still offered without the least appreciation of what a real boiler is or should be.

The Point Is This

FOR those readers who want to get it on the run, Mr. Lykken's militant argument may be summed up as follows:

1 — To avoid the endless confusion created by the common use of the meaningless term "furnace temperature," let us consider "temperature of generation."

2 — "Temperature of generation" corresponds to no actual temperature in any part of the furnace; it does measure directly the heat evolved in the furnace. "Temperature of generation" is the final gas temperature that would be obtained with the given percentage of CO_2 if the coal were burned in an insulated, 100-per cent refractory, furnace (no boiler tubes present) — that is, if all of the heat evolved stayed in the gases. Call it "T.G." for short.

3 — In the "good old days" of 8 or 9 per cent CO_2 T.G. was 2,000 to 2,250 deg. F. Hence no radiant heat absorption was necessary to avoid operating troubles.

4 — Raise the CO_2 to 14 or 15 per cent, as in a modern boiler, and the T.G. rises to 3,500 deg. Since the temperature of gases entering the first pass should not exceed 2,000 deg., and since the stack temperature will be about 500 deg., this simply means that at least 50 per cent of all the heat absorbed by the boiler must enter it by radiation.

5 — The time has passed, therefore, when boilers should be bought on the basis of the obsolete 10 sq.ft. per meaningless boiler horsepower. They must be selected on the basis of their capacity to absorb by radiation a given amount of the total heat input and to absorb by convection as much as possible of the remaining heat in the gases.

6 — Boiler manufacturers must assume responsibility for absorbing heat *when, where* and *as* generated. The boiler must be built around a given condition of flame or fuel bed.

7 — Too many mere arrangements of tubes and drums are still offered without the least appreciation of what a real boiler is or should be.

▼

ALL BEARING LUBRICATION IS PRESSURE LUBRICATION

Experiments of Parish and Cammen show that minute cavities in shaft and bearing surfaces act as reservoirs for oil under tremendous pressure

▼

THE basic science of lubrication, studied for years, is still in the early stages of its development. Why, fundamentally, one lubricant works better than another is still to be determined. Judging by the practical results of research in other fields, much will be gained by a clearer knowledge of all that takes place in the film or films between a lubricated shaft and its bearings. In fact, it now appears that this study must be extended a minute distance into the metal itself, since it has been proved that the lubricant "penetrates" the surface of the metal.

This finding was announced at a recent meeting in New York of the American Society of Mechanical Engineers, by William F. Parish, chairman of the Lubrication Engineering Committee of the Petroleum Division, and by Leon Cammen, consulting engineer. Their conclusions were based on research sponsored by the Lubrication Engineering Committee and involving the use of a testing machine capable of producing shaft rotation at speeds up to 18,000 r.p.m. This brief summary of the research work and its practical conclusions is based on information supplied by Messrs. Parish and Cammen.

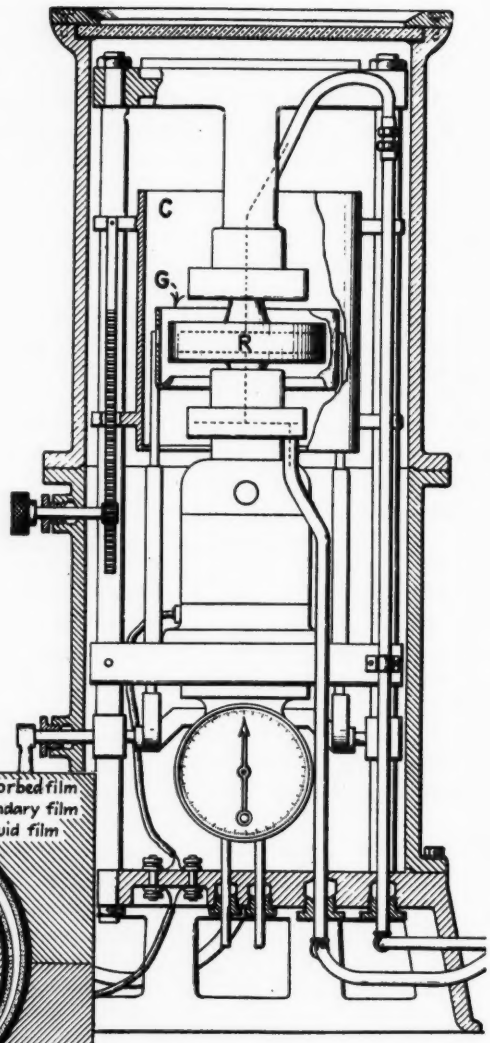


Fig. 1—Sperry-Cammen lubricating-oil testing machine

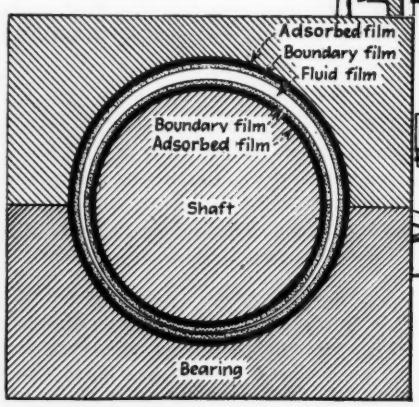


Fig. 2 — Diagram indicating present accepted theory of bearing lubrication

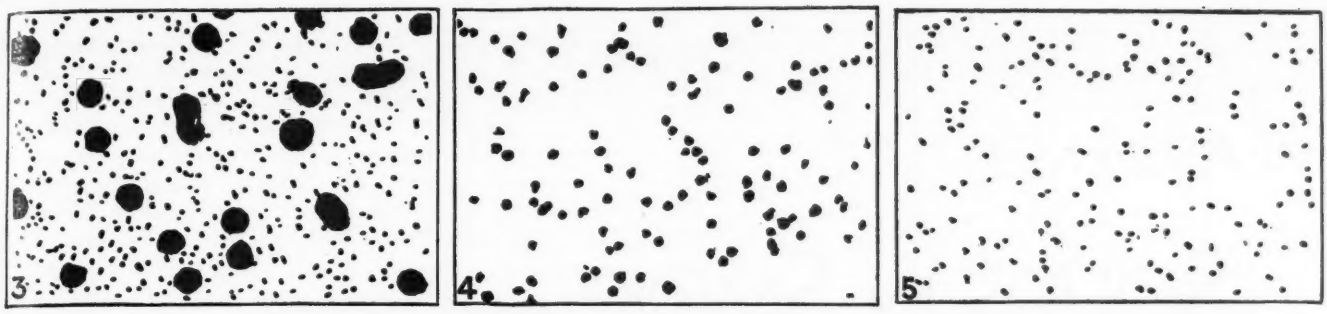
First, consider the present accepted theory of bearing lubrication, as illustrated in Fig. 2. According to this theory there is an adsorbed film of condensed gases on the surface of the shaft, and a similar film on the bearing. Next to each of these adsorbed films, according to the previous theory, is a boundary film of lubricant—one molecule thick, according to Langmuir. This film is assumed to be stationary with respect to the adjacent metal of shaft or bearing.

Outside of each Langmuir layer is said to be a "Coulomb-Law" layers, whose thickness is many thousand times the thickness of one molecule. Between the "Coulomb-Law" layers of the shaft and bearing, respectively, lies the fluid oil.

The new theory of Parish and Cammen corresponds in the main to the old, except that it presents a new picture of the adsorbed layer, and indicates for it far greater importance than had been imagined.

This layer, say Parish and Cammen, consists not of condensed gases, but of lubricant in an extremely thin sheet, fed by microscopic reservoirs in the surface of the metals, in which reservoirs the oil is stored under tremendous pressures.

So minute are these crevices that molecular forces—probably magnetic or electrical in nature—come into play. Centrifugal force equivalent to more than 9,000 times the weight of the oil will not detach this film from a shaft. A shaft, when whirled dry to this layer can be proved still damp with oil by wiping with bond



Figs. 3 to 5—Three times size of the oil drops thrown off by the test machine at 500, 3,000 and 6,000 r.p.m. respectively, with castor oil on a bronze rotor

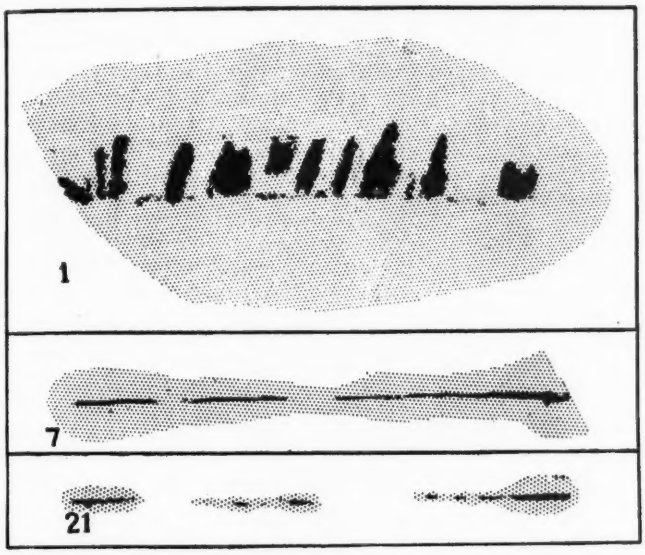


Fig. 6—Three of 21 indications of oil films obtained by holding bond paper against the test-machine rotor during one test (lard oil on a steel rotor)
Indications are that the dark areas are produced by a compound of metal and oil, while the bond paper is against the rotor, and the light areas are pure oil. The 1st, 7th, and 21st wipings are shown

paper. Wiped dry, it again becomes damp with oil fed under pressure from the surface reservoirs. In one case this wiping dry and rewetting from within the metal was repeated twenty times before no more lubricant could be removed by the bond paper.

Practical users of lubricants have long known that good oils have a property of "oiliness" hard to define, except in terms of operating results. They have known, too, that this essential property of good lubricating oil has little relation to viscosity. Since conventional testing machines for lubricants have lumped together a variety of properties, including viscosity, the results of such tests have often been out of line with the service of lubricants under field conditions.

The work of Parish and Cammen indicates that a good lubricating oil should combine low viscosity in the free film midway between shaft and bearing, with a powerful affinity for shaft and bearing metal which will maintain the adsorbed surface films and the pressure reservoirs that feed them as fast as they are wiped dry. In compounded oils, the experimenters point out, one constituent may form the surface films and another the free layer, thus producing an ideal combination.

A brief description of the testing machine and review of the experiments may be of interest. Fig. 1 shows the Sperry-Cammen tester for fluids and metals (both the fluids and the metals are factors in the lubricating problem). The rotor *R* will operate up to 18,000 r.p.m. without vibration. Cylinder *C* is adjustable vertically and is used to hold the paper on which the drops of oil strike when thrown off the rotor. *G* is a guard, also with a vertical adjustment, that may be used to prevent the oil drops from the rotor being thrown on cylinder *C*.

In making a test, oil of a given quality is applied to the rotor, which is then brought up to speed. At the desired speed the guard *G* is lowered, and oil drops are allowed to be thrown out onto the paper on the inside of the cylinder *C*.

With the guard again in position a clear section of paper is brought into position, and the rotor's speed increased to the value for the next test. The guard is again lowered, and a second sample of drops allowed to strike the paper. This procedure is continued, step by step, until a speed is reached above which no more drops are thrown off.

Figs. 3, 4 and 5 indicate the sizes of drops obtained at various speeds with castor oil on a bronze rotor. The droplets, as shown in the figures, are enlarged about three times. With increasing speed the drops grow smaller and smaller, until, at a speed around 8,000 r.p.m., no more oil is thrown off, even if the speed of the rotor is greatly increased.

At this stage the rotor might be assumed to be dry, yet a substantial film of oil can be picked up by rubbing it with a piece of folded bond paper. As mentioned before, the wiped rotor does not remain dry, but picks up a new film, which can come only from reservoirs below the surface of the metal. Layer after layer is wiped off and replaced, until finally the reservoirs are dry. Fig. 6 shows three of 21 indications of film that were wiped off in one case and were obtained with lard oil on steel. Indications are that the dark areas are produced by a compound of metal and oil, while the light areas are pure oil. The 1st, 7th and 21st wipings are shown. Each wiping lasted for about five seconds, with about 10 sec. between wipings. The first wiping was made when the rotor was revolving at about 8,000 r.p.m. and the 21st at about 2,000 r.p.m.

The fact, already mentioned, that the oil so removed could not be detached by centrifugal force equal to 9,000 times the oil's weight gives some idea of the tremendous molecular attractions that hold the film to the metal.

It is too early to predict the practical consequences of this new theory of lubrication. It would appear, however, that Cammen and Parish have hit upon something fundamental, which, through the efforts of designing engineers, oil manufacturers and lubrication specialists, will help power engineers and others to get safer and more efficient lubrication at lower cost.

MEASUREMENT OF SOLIDS IN SMOKE

By ELY C. HUTCHINSON

Editor of Power

ALTHOUGH solids in gas streams have concerned engineers and the lay public for many years, they are still a baffling problem from whatever point of view they are considered. The public demands their removal as an atmospheric pollutant. Operators of industries, which in the very nature of the present knowledge of their respective arts seem destined to produce dust- or dirt-laden fumes, are sensitive of their responsibility but are limited at the same time by strong economic and technical considerations. An up-to-the-minute digest of the engineering aspects of the problem clearly points to the necessity for establishing the fundamental ground work without which no successful solution can be assured the public.

Need for Health Standards

Consider first the solids discharged from power house stacks. Although these are but a part of all the wind-borne solids, of which the public properly complains, they are its chief point of attack at present.

It is obviously much simpler and less expensive to remove, let us say, 45 per cent of the solids from power house stack discharges than 90 per cent, so the question arises as to how much of the solid content must be removed from the gas streams in order to remove the health menace. This question is as yet unanswered, but there is promise, because the U. S. Public Health Service is conducting research investigations simultaneously in fourteen large cities throughout the country, with the expectation that an answer will be found. Field work has been in progress for a year and is expected to continue for another, following which correlation and analytical studies must be made. It does not seem likely, therefore, that an authoritative answer to the question of what amount of solids is a health menace will be available for two years and perhaps longer.

In the meantime, efforts are being made to find some way of actually determining what solids are being discharged from stacks. Although it sounds simple enough, there is as yet no clearly defined and generally acceptable method for obtaining accurate gas samples. This statement, to a lesser extent, also holds good for sampling to determine solid contents in atmosphere. More than thirty different types of apparatus have been made for sampling purposes. These fall generally into groups using the basic principles of condensation, filtration, washing and impinging, electrostatic, optical and specific gravity separation.

An imposing bibliography of numerous studies in this country and abroad already exists in testimony of the extreme interest and serious thought being given to the whole subject. The Smoke Abatement Division of the Research Department, Stevens Institute of Technology, has, with the cooperation of the Interborough Rapid Transit Company and the Research Corporation, both of New York City, just about concluded a two-year study for the express purpose of evaluating the various methods at present on the market for the measurement of solid suspended matter in gas streams. The report of this study, when issued, will be a valuable contribution.

The Pure Air Committee of the American Society of Mechanical Engineers is sponsoring a basic research project on the solid content of chimney gases as an essential preliminary to the development of acceptable methods for testing dust catchers. It is expected that this project will require at least two years for completion.

It is not intended that these statements shall give the impression that nothing has been done so far. Manufacturers of dust catchers at present on the market have in some cases done splendid work and to a great extent have been leaders in the thinking necessary to the complete solution of the problem.

Much of the best work of recent years has been carried out under the auspices of the Institute of Fuel at London, England. The mining, chemical and cement industries have done a lot and are said to have successfully solved the problem of measuring solids in their fields, so there is every expectation that before long there will be a much better general understanding of what is needed in smoke and dust control and how to accomplish it in the power field.

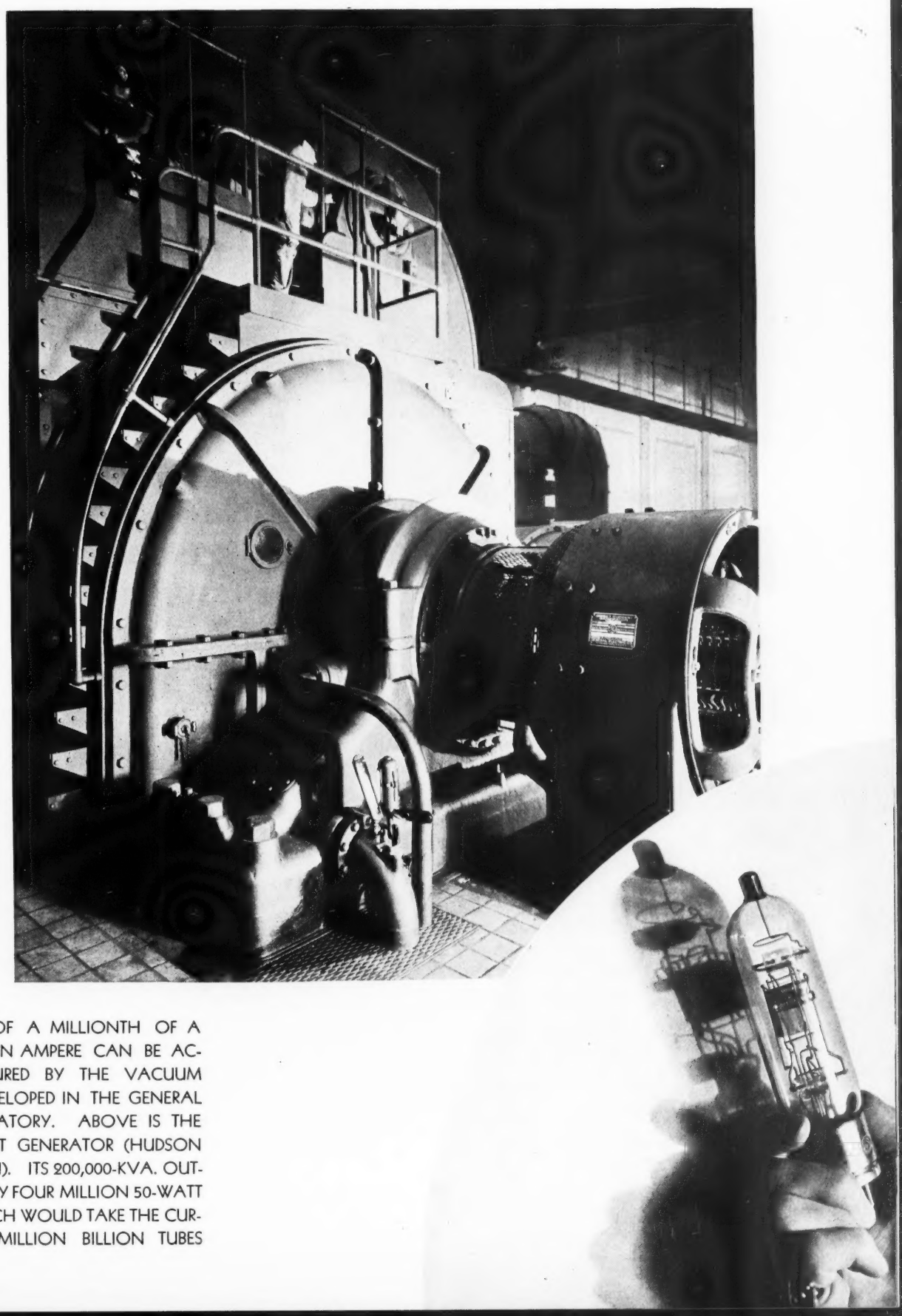
Duct Models for Gas Flow

It has been quite customary for designers to place boilers and stacks at the point of maximum convenience to topography and architectural layout and to disregard the conditions of gas flow between the two. Right-angle turns in horizontal or vertical plane, or both, have seldom worried the designer. The influence of turns and bends on the streamlines of air and gas flow have too long escaped the consideration they deserve.

A little consideration of the subject and a study of the laws of streamline and turbulent flow and also the influence of the shape of ducts upon the efficiency of flow, will point immediately to the following suggestion:

If for reasons of major importance it is essential that boilers and stacks must be so located as to prevent an efficient design of duct work connecting the two, such as would straighten out the lines of gas flow and permit the ready and accurate sampling of gas streams for solid content, then small-scale models should be made of the duct work for each individual plant. These should be experimented with to determine what connections and baffling should be permanently installed in the full-size job to assure the proper setting or distribution of the gas stream. If this is done, accurate and if desired, continuous, gas samples can be taken.

GNAT MEETS ELEPHANT



A HUNDREDTH OF A MILLIONTH OF A BILLIONTH OF AN AMPERE CAN BE ACCURATELY MEASURED BY THE VACUUM TUBE (RIGHT) DEVELOPED IN THE GENERAL ELECTRIC LABORATORY. ABOVE IS THE WORLD'S LARGEST GENERATOR (HUDSON AVENUE STATION). ITS 200,000-KVA. OUTPUT WOULD SUPPLY FOUR MILLION 50-WATT LIGHT BULBS. EACH WOULD TAKE THE CURRENT OF FIFTY MILLION BILLION TUBES

TIDE WATER TESTS 12

TYCOL'S *Longer Life and*

Revolutionary Process Extracts Sludge-forming Impurities Left In Turbine and Diesel Oils by Usual Methods

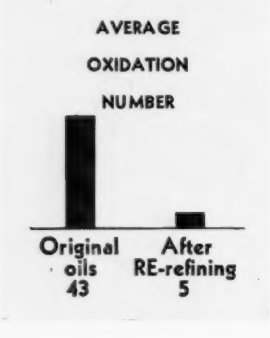
Tide Water bought, in the open market, 12 different finished brands of turbine and Diesel lubricating oils and *re-refined* them by Tide Water's Special Edeleanu Process.

The results were startling. Each of the 12 oils yielded extracts . . . ranging from 9.8% to 25.3% of their original volume!

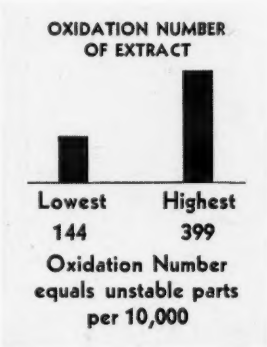
These extracts . . . with oxidation numbers of 144 to 399 . . . are worse than useless for lubrication. They are actually harmful . . . they produce sludge, acidity, carbon . . . and cause premature breakdown of the oils.

The re-refined oils showed an average oxidation number of 5 . . . as compared to 43, their original average number!

WHAT THESE TESTS PROVE . . . These tests prove that Tide Water's Process represents a great advance over conventional methods.



Here are the reasons: The Process is a physical solvent treatment. It dissolves ALL unstable hydrocarbons, found even in the best of crudes. It starts NO chemical reaction upon the components of oil, stable or unstable. It forms NO new unstable substances. And it preserves the pure and stable hydrocarbons of highest lubricating value.



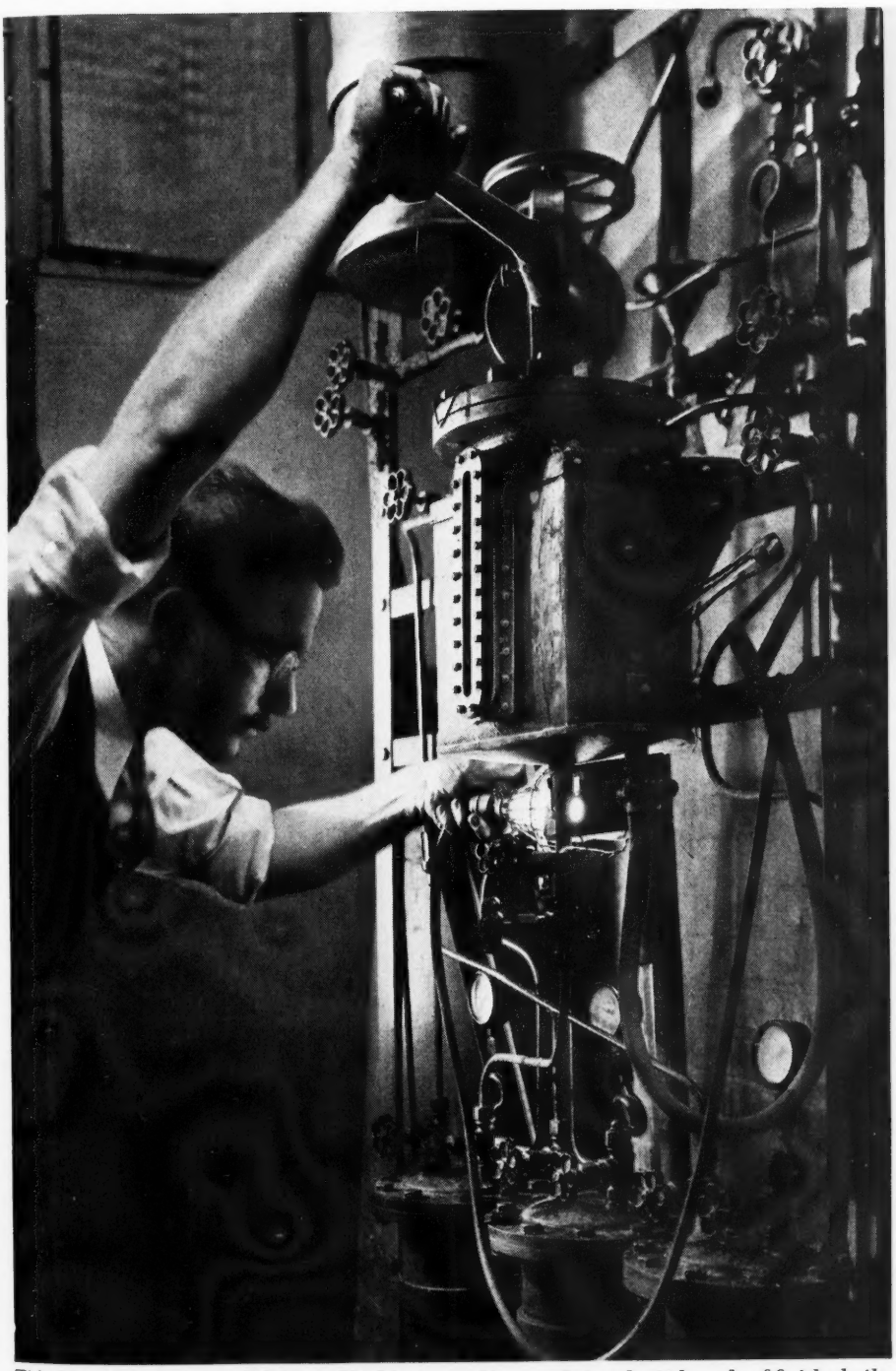
That is why Tycol Turbine and Diesel Oils, being 100% paraffine base, and refined by this Process, have purity and stability which no other oils possess. Tycol oils have oxidation numbers ranging from 1/4 to 1/50 of those of competitive grades.

THE REAL PROOF IS SERVICE . . . In the final analysis, it is service that counts. Everything shown in these laboratory tests is borne out in experience. Tycol oils have set up new records of performance for some of the country's leading producers of power.

Based on these records, you can depend on Tycol oils for low acidity, low carbon deposition and better demulsibility. You can depend on them for stability, for non-sludging, long-lasting, efficient, economical lubrication!

COMPETITIVE OILS BY RE-*refining*

Greater Stability Proved



Tide Water's Laboratory Edeleanu Machine... used in re-refining the 12 brands of finished oils. Each oil was run through this machine four times... thus duplicating exactly the refining process through which Tycol Turbine and Diesel Oils must pass, in Tide Water's Edeleanu Plant.

KNOW YOUR OILS

So sure is Tide Water of Tycol superiority that it is making an unprecedented offer to buyers of turbine and Diesel oils. Tide Water will be glad to *re-refine for you,* by its Edeleanu Process, a sample of the turbine and Diesel lubricating oils you are now using. Not only that, Tide Water will welcome the presence of your own technologists, at the time.

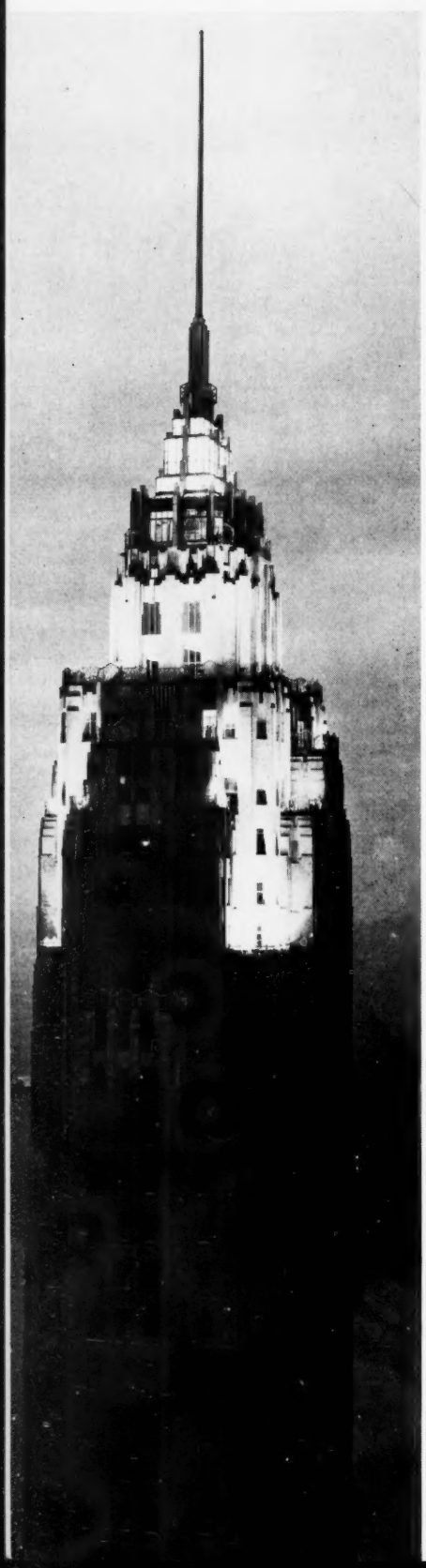
Write for the complete Laboratory Report, "Re-refining 12 Brands of Oils." Tide Water Oil Sales Corporation, 17 Battery Place, New York.

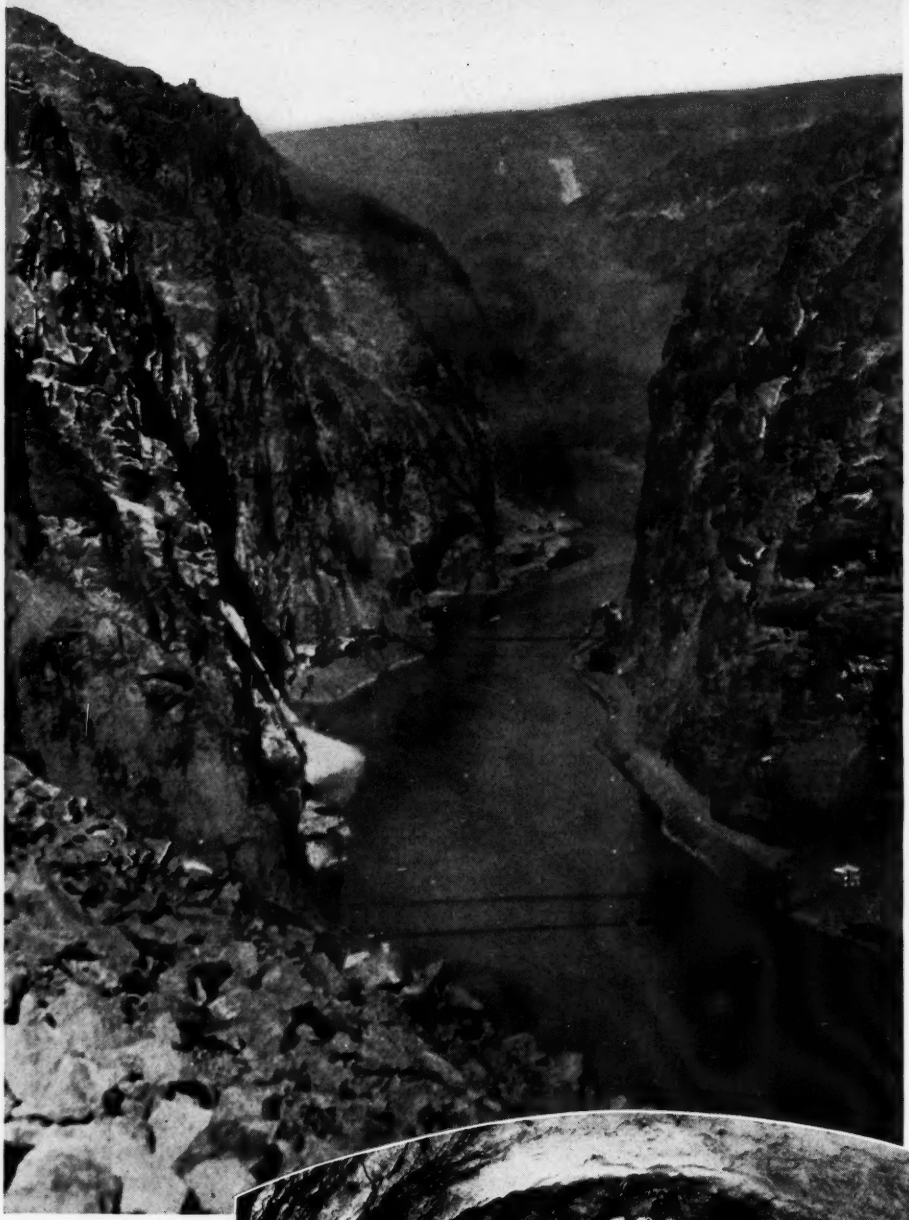
INDUSTRIAL
TYCOL
OILS-GREASES

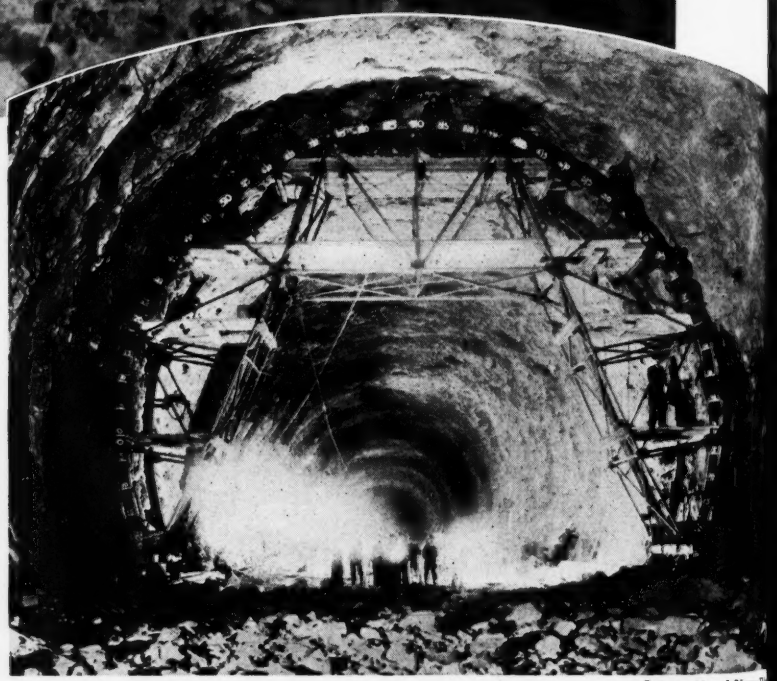
TIDE WATER

HOT WATER

FOR THE FIRST TIME IN HISTORY, HOT WATER FOR HEAT IS PUMPED TO THE TOP OF A SKYSCRAPER—THE NEW CITIES SERVICE BUILDING, 60 WALL STREET, NEW YORK CITY. THE HIGHEST RADIATOR STACK IS 770 FT. ABOVE THE BASEMENT PUMPS. THE RESULTING PRESSURE HEAD IS 330 LB.



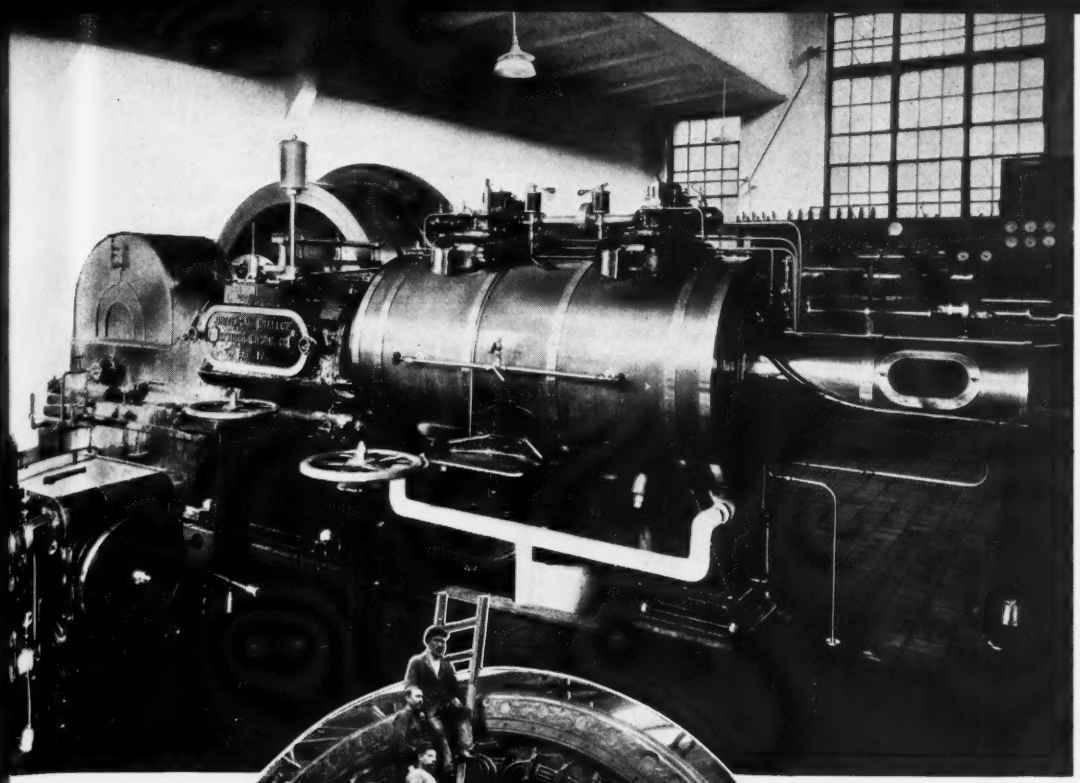




International News P

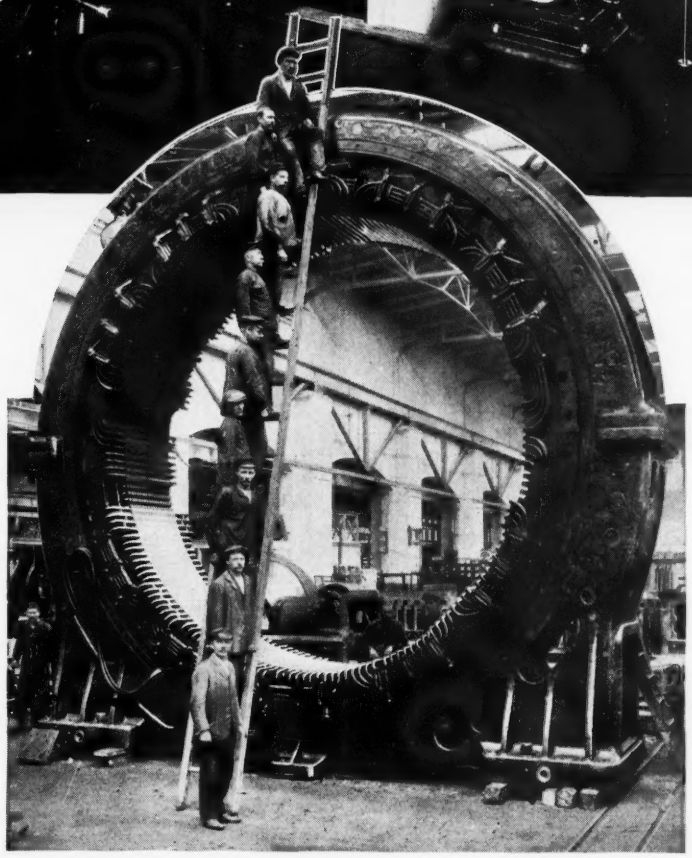
—AND COLD

TO HARNESS COLORADO RIVER FOR POWER AND IRRIGATION THE HOOVER DAM—WORLD'S HIGHEST (735 FT.)—WILL SOON SPAN THIS ROCKY CANYON NEAR LAS VEGAS, NEVADA. BELOW MAY BE SEEN ONE OF FOUR TUNNELS, EACH 56 FT. IN DIAMETER, WHICH WILL TEMPORARILY DIVERT THE FLOW



STEAM

FROM ITS CENTRAL OFFICE IN NEW YORK CITY THE NATIONAL BISCUIT COMPANY DIRECTS THE OPERATION OF ITS EIGHTY-FIVE BRANCH FACTORIES THROUGHOUT THE UNITED STATES AND CANADA. POWER-PLANT OPERATION IS A MAJOR ACTIVITY. STEAM ENGINES IN THE DETROIT FACTORY (HERE SHOWN), AND IN MANY OTHERS, HARNESS PROCESS STEAM



ELECTRICITY

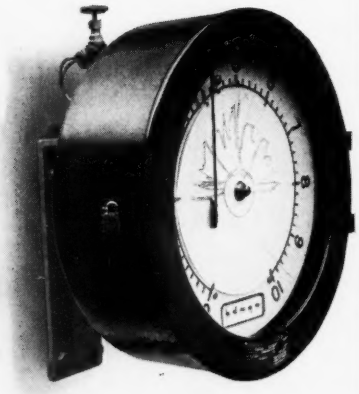
STATOR OF 11,000-KVA., 25-CYCLE GENERATOR FOR TROLLHÄTTAN, SWEDEN'S LARGEST HYDRO-ELECTRIC STATION. IN THE MODERNIZATION OF TROLLHÄTTAN DESCRIBED IN *POWER*, JUNE 21, TWO OLD TURBINES WERE REBUILT FOR GREATER CAPACITY AND AN ADDITIONAL GENERATOR WAS COUPLED TO EACH SHAFT

Photo by the Linde Air Products Co.

WELDS

WELDING IS NOW WIDELY USED FOR POWER-SERVICE AND PROCESS PIPING. THIS PICTURE WAS TAKEN IN A LARGE EASTERN PROCESS PLANT, NOW NEARING COMPLETION, WHERE ALL PIPING FOR STEAM, WATER, AIR AND GASES IS FABRICATED BY OXY-ACETYLENE TORCHES

COCHRANE PIPE FLOW METER

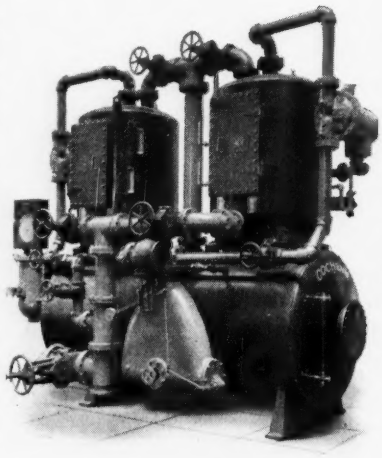


Combines Accuracy with Reliability

THE exceptionally high torque or moment developed by the Cochrane Tilting U-tube, together with the very small frictional and other resistances, gives a high degree of accuracy. A test weight is provided by means of which the accuracy can quickly be checked at any time. There are no working parts in the pressure chambers and there is no stuffing box. The chart and the pointer scale have equally spaced divisions for equal increments of flow. The integrator is direct reading, like an automobile mileage counter.

Ask for Bulletin L-680.

COCHRANE METERING DEAERATING HEATER



Meters Feed Water, Prevents Corrosion, Saves Fuel

THE water is first heated quite to steam temperature and the oxygen eliminated. It then passes over a V-notch meter in the storage chamber and the Cochrane V-notch Recorder indicates, records and totalizes the flow. This one piece of apparatus therefore performs the triple service of protecting boilers, piping and turbines, improving plant efficiency and keeping a check upon efficiency.

Ask for Bulletin L-679-A.

COCHRANE V-NOTCH RECORDER

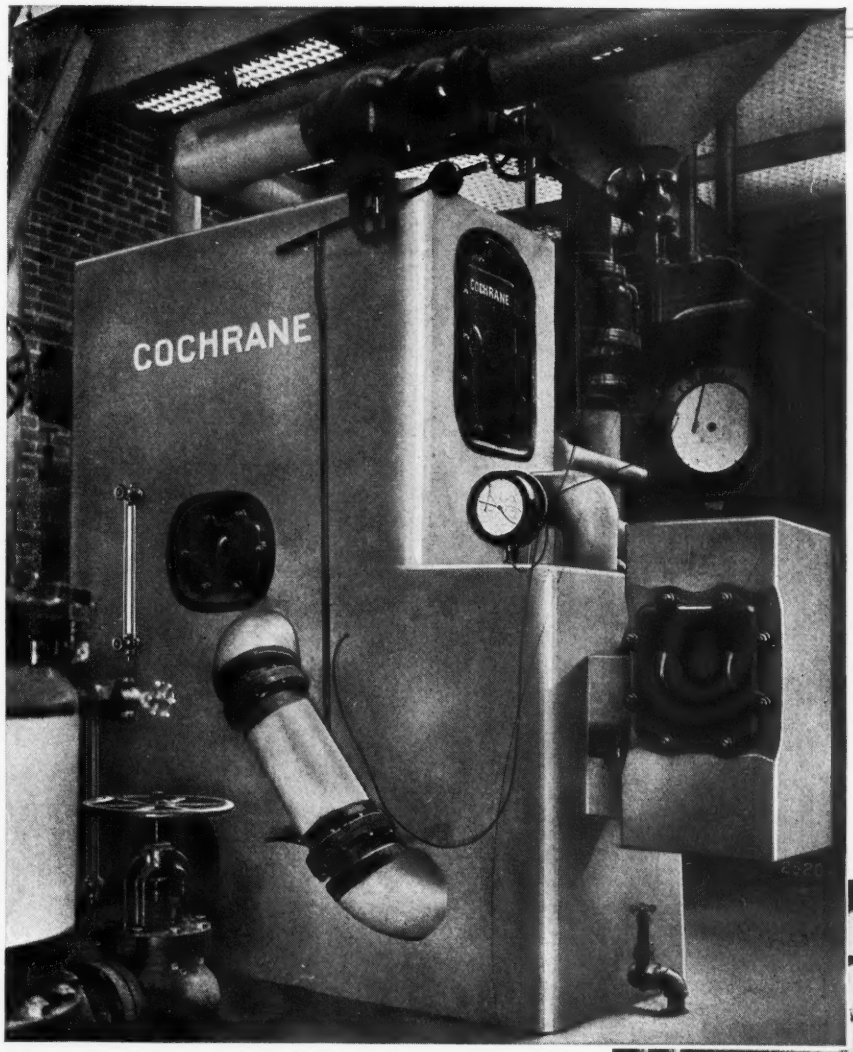
Is Accurate With Varying Flow

THE head on a V-notch varies rapidly as the flow approaches zero, resulting in a close percentage accuracy at small fractional flows as well as at rated capacity, in which respect the Cochrane V-notch Meter greatly surpasses any other type of flow meter. The Cochrane V-notch Recorder has a simple and husky mechanism operated by a cam carried directly by a powerful float, without rack and pinion, cable and drum or other intermediate transmission. The pointer scale and chart divisions are equally spaced for equal increments of flow and the integrator reads directly, like an automobile mileage counter.

Ask for Bulletin L-679-A.

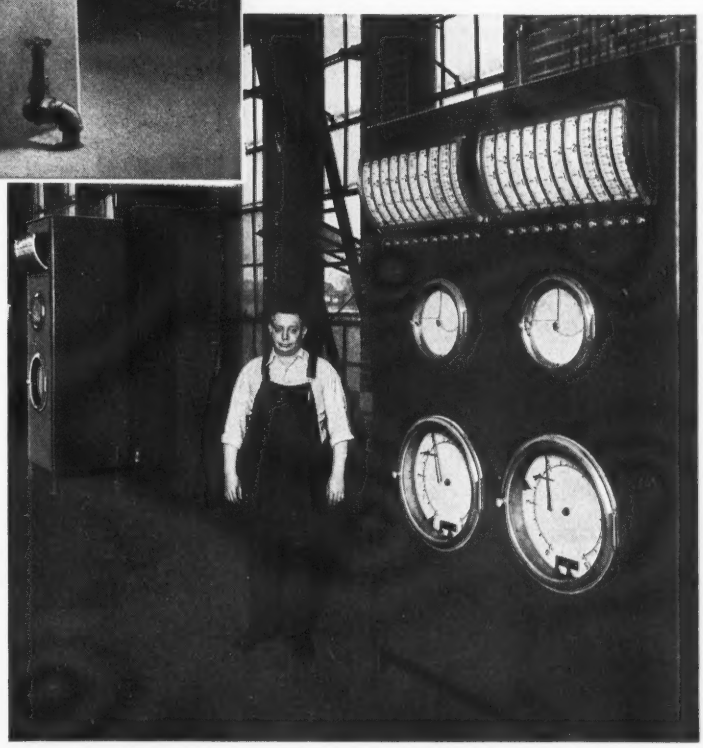
COCHRANE CORPORATION

17th & Clearfield Streets, Philadelphia, Pa.



Total Feed Water Heated, Deaerated and Metered

Steam from Each Boiler Metered



THE steam plant of the Indianapolis City Hospital has been fully equipped with control instruments to facilitate efficient operation.

The boiler feed water is brought to the full temperature of the exhaust steam, made non-corrosive by driving off dissolved oxygen and accurately measured, recorded and totalized by a Cochrane Metering Deaerating Heater, while the steam delivered from each of the three boilers is measured, recorded and totalized by a Cochrane Pipe Flow Meter.

The engineer in charge thus has a continuous record of plant operation, from which he can calculate boiler room performance under all conditions of operation.

COCHRANE CORPORATION

17th & Clearfield Streets, Philadelphia, Pa.

H-46

POWER'S DATA SHEETS
NUMBER 1—PART 1

POWER UNIT CONVERSIONS

THESE tables, with those to appear in the August number, were specially laid out and computed for *Power* and represent a selection based solely on the special needs and practices of power engineers. These bring together, in the most convenient form, conversions of the basic English units of length, area, volume, weight, velocity, rate of flow, unit weight, pressure, energy and power.

Any listed factor multiplied by a quantity expressed in the unit printed at the left on the same line will give the equivalent quantity in the unit heading the column.

Where "L" or "R", with a number, is printed immediately below the factor, move the decimal point *Left* or *Right* (respectively) the indicated number of places.

All factors are carried to five significant figures (except where the factor is exact with a smaller number). One or two figures at the end may be dropped where slide-rule accuracy is sufficient.

LENGTH

	Inches	Feet	Yards	Miles
Inches...		.83333 L 1	.27778 L 1	.15782 L 4
Feet.....	12		.33333	.18939 L 3
Yards....	36	3		.56818 L 3
Miles....	63360	5280	1760	

VOLUME

	Cubic Inches	Gallons	Cubic Feet	Cubic Yards	Acre Feet
Cubic Inches...		.43290 L 2	.57870 L 3	.21433 L 4	
Gallons.....	231		.13368	.49511 L 2	.30689 L 5
Cubic Feet.....	1728	7.4805		.37037 L 1	.22957 L 4
Cubic Yards...	46656	201.97	27		.61983 L 3
Acre Feet.....		32585 R 1	43560	1613.3	

AREA

	Circ. Mils.	Square Inches	Square Feet	Square Yards	Acres	Square Miles
Circular Mils....		.78540 L 6				
Square Inches....	12732 R 2		.69444 L 2	.77160 L 3	.15942 L 6	.24909 L 9
Square Feet.....		144		.11111	.22957 L 4	.35870 L 7
Square Yards....		1296	9		.20661 L 3	.32283 L 6
Acres.....		62726 R 2	43560	4840		.15625 L 2
Square Miles....		40145 R 5	27878 R 3	30976 R 2	640	

WEIGHT

	Grains	Ounces	Pounds	Tons (Short)	Tons (Long)
Grains.....		.22858 L 2	.14286 L 3	.71428 L 7	.63775 L 7
Ounces.....	437.5		.0625	.3125 L 4	.27902 L 4
Pounds.....	7000	16		.5 L 3	.44643 L 3
Tons (Short).....	14000 R 3	32000	2000		.89286
Tons (Long).....	15680 R 3	35840	2240	1.12	

WEIGHT RATES

(Month used is exactly one-twelfth year; Ton is 2,000 lb.)

	Lb. per Sec.	Lb. per Min.	Lb. per Hour	Lb. per Day	Lb. per Month	Lb. per Year	Ton per Min.	Ton per Hour	Ton per Day	Ton per Month	Ton per Year
Pounds per Second.....		60	3600	86400	26280 R 2	31536 R 3	.3 L 1	1.8	43.2	1314	15768
Pounds per Minute.....	.16666 L 1		60	1440	43800	52560 R 1	.5 L 3	.3 L 1	.72	21.9	262.8
Pounds per Hour.....	.27778 L 3	.16666 L 1		24	730	8760	.83333 L 5	.5 L 3	.12 L 1	.365	4.38
Pounds per Day.....	.11574 L 4	.69444 L 3	.41667 L 1		30.417	365	.34722 L 6	.20833 L 4	.5 L 3	.15208 L 1	.1875
Pounds per Month.....	.38052 L 6	.22831 L 4	.13699 L 2	.32877 L 1		12	.11415 L 7	.68490 L 6	.16438 L 4	.5 L 3	.6 L 2
Pounds per Year.....	.31710 L 7	.19026 L 5	.11415 L 3	.27397 L 2	.83333 L 1		.95130 L 9	.57075 L 7	.13698 L 5	.41667 L 4	.5 L 3
Tons per Minute.....	33.333	2000	12000 R 1	28800 R 2	87600 R 3	10512 R 5		60	1440	43800	52560 R 1
Tons per Hour.....	.55555	33.333	2000	48000	14600 R 2	17520 R 3	.16666 L 1		24	730	8760
Tons per Day.....	.23146 L 1	1.3889	83.333	2000	60833	73000 R 1	.69444 L 3	.41667 L 1		30.417	365
Tons per Month.....	.76103 L 3	.45662 L 1	2.7397	65.753	2000	24000	.22831 L 4	.13699 L 2	.32877 L 1		12
Tons per Year.....	.63420 L 4	.38052 L 2	.22831	5.4795	166.67	2000	.19026 L 5	.11415 L 3	.27397 L 2	.83333 L 1	

TIME

(Month used is exactly one-twelfth year)

	Seconds	Minutes	Hours	Days	Months	Years
Seconds		.16667 L 1	.27778 L 3	.11574 L 4	.38052 L 6	.31710 L 7
Minutes	60		.16667 L 1	.69444 L 3	.22831 L 4	.19026 L 5
Hours	3600	60		.41667 L 1	.13699 L 2	.11415 L 3
Days	86400	1440	24		.32877 L 1	.27397 L 2
Months	26280 R 2	43800	730	30.417		.83333 L 1
Years	31536 R 3	52560 R 1	8760	365	12	

VELOCITY

	Inches per Sec.	Inches per Min.	Inches per Hr.	Feet per Sec.	Feet per Min.	Feet per Hr.	Miles per Min.	Miles per Hr.
Inches per Second		60	3600	.83333 L 1	5	300	.94697 L 3	.56818 L 1
Inches per Min.	.16667 L 1		60	.13889 L 2	.83333 L 1	5	.15783 L 4	.94697 L 3
Inches per Hour	.27778 L 3	.16667 L 1		.23148 L 4	.13889 L 2	.83333 L 1		.15783 L 4
Feet per Sec.	12	720	43200		60	3600	.11364 L 1	.68182
Feet per Min.	.2	12	720	.16667 L 1		60	.18939 L 3	.11364 L 1
Feet per Hour	.33333 L 2	.2	12	.27778 L 3	.16667 L 1		.31566 L 5	.18939 L 3
Miles per Min.	1056	63360		88	5280	31680 R 1		60
Miles per Hour	17.6	1056	63360	1.4667	88	5280	.16667 L 1	

HEATING WITH REFRIGERATING EQUIPMENT CUTS CURRENT COSTS

By H. L. DOOLITTLE
Chief Designing Engineer,
Southern California Edison Co., Ltd.

Under most favorable conditions a performance ratio of 2.32 is indicated by these tests on the first large-scale installation of refrigeration heating, that in the Los Angeles office of Southern California Edison Co.

THE office building of the Southern California Edison Company, Ltd. in Los Angeles is equipped for direct heating of the entire building by electricity. In addition a complete ventilating system is installed to supply conditioned air to all offices. The heating and air conditioning equipment was described in a previous article.[1]

When the building was being planned it was decided to install such additional equipment as was necessary to try out the heat pump principle which makes use of the refrigerating equipment in winter for heating purposes. All necessary equipment for making this trial was a part of the regular air-conditioning system except that a heater had to be installed through which the condenser water could be circulated for heating the air supplied to the building. As the air-conditioning system is divided into two parts, it was decided to install a heater on the upper, or tower, system only, postponing the purchase of a heater for the lower system pending the results of tests and operating experience.

Briefly, the equipment used in the heating tests involves a 120-ton methyl-chloride rotary compressor, a 2,790-sq.ft. condenser, a 2,250-sq.ft. vertical tube cooler, a 10,500-sq.ft. fin-tube heater, and a two-stage air washer with necessary pumps and auxiliaries.

Heat Is "Pumped" from Roof to Rooms

The cycle of operation is as follows: the refrigerant gas, after being compressed, is passed to the condenser where heat is removed, condensing the refrigerant to a liquid. The heat given up by the refrigerant in the condenser is absorbed by the condensing water, which is then pumped through the fin-tube heater located in the path of the air supplied to the building. Here the air is heated and the condensing water temperature is lowered. The liquid refrigerant is passed through an expansion valve to the cooler where it is converted into a gas, thereby absorbing heat from the water being circulated through the cooler. The cooled water from the cooler is then passed through the air washer on the roof, where it absorbs heat from the outside air.

In this system it is seen that heat is absorbed from the outside air by the cooler water, that this heat is in turn absorbed by the refrigerant, and then by the condenser circulating water, and is finally transferred to the air going to the building. This principle of heating can be utilized wherever a source of heat is available, such as a body of water or the atmosphere, *if these sources are not at too low a temperature.* It must also be remembered that the cycle does not lend itself to the efficient production of high temperatures. The closer the high and low temperatures the greater is the efficiency.

Many Tests Made Last Winter

The building was completed and occupied last year. During the past winter the refrigerating equipment has

[1] *Power*, Sept. 8, 1931.

been operated extensively for heating purposes and tests have been made to determine performance under various conditions. The accompanying tables give the averages of observations made during eight separate runs. These tests were made not only to determine the efficiency under normal operating conditions, but also to see to what extent auxiliary power could be saved without interfering too greatly with performance.

Table I gives results calculated from the data in the other tables. A brief explanation of the method of arriving at the results follows:

Table I — Results of Test on Refrigeration Heating Cycle

Test Number	Compressor Input, Hp.	Auxiliary Power, Hp.	Total Input, Hp.	Cooler B.t.u. per Min.	Cooler B.t.u. Plus Power to Compressor, B.t.u. per Min.	Heat Absorbed Condenser Water, B.t.u. per Min.	B.t.u. to Condenser. / Total Power Input, Hp.	B.t.u. to Condenser. / Total Power Input, B.t.u.	B.t.u. to Condenser. / Hp. Input to Compr.	B.t.u. to Condenser. / B.t.u. Input Compr.	Compressor Hp. per Ton	Total Hp. per Ton
	A	B	C	D	E	F	G	H	I	J	K	L
1	145.11	139.46	284.57	15,620	21,250	21,000	73.8	1.74	144.8	3.415	1.86	3.65
2	162.71	138.99	301.70	16,000	22,350	18,600	61.8	1.455	114.4	2.70	2.035	3.76
3	175.01	138.57	313.58	15,000	21,860	20,600	65.8	1.55	117.5	2.775	2.335	4.18
4	170.61	138.72	309.33	15,300	21,980	21,800	70.5	1.664	127.8	3.01	2.23	4.04
5	167.11	87.43	254.54	14,980	21,530	21,000	82.4	1.945	125.5	2.958	2.235	3.40
6	165.81	122.52	288.33	14,610	21,090	20,200	70.2	1.655	122.0	2.865	2.265	3.95
7	165.61	70.90	236.51	12,900	19,370	19,800	83.8	1.98	119.5	2.825	2.57	3.67
8	164.81	81.21	246.02	14,430	20,870	19,400	78.9	1.855	117.8	2.78	2.28	3.415

All tests were made with one compressor, one condenser, one cooler and one cooling tower in operation. Tests Nos. 1, 2, 3, and 4 were made with different amounts and temperatures of air supplied to the air heater, all other conditions normal.

Test No. 5 — Cooling tower fan run at reduced speed.

Test No. 6 — Same as test No. 4 except second stage pump of cooling tower shut down.

Test No. 7 — Same as test No. 5 except second stage pump of cooling tower shut down.

Test No. 8 — Same as test No. 7 except cooler water increased.

The compressor horsepower input (Column *A*) includes the excitation for the synchronous motor and is therefore the total input to the motor.

The auxiliary power (Column *B*) is the total power input to the motors driving all auxiliaries, such as cooling tower fan and pump, condenser water pump, cooler pump, etc.

The total power input (Column *C*) is the sum of Column *A* and Column *B* and represents the total power expended in the heating operation.

Table II — Electrical Input — Horsepower Average

Test No.	Compressor	Condenser Pump	Cooler Pump	2nd Stage Pump	Cooling Tower Fan
1	145.1	30.1	27.7	16.53	65.13
2	162.7	30.1	27.7	16.45	64.74
3	175.0	30.1	27.5	16.44	64.53
4	170.6	30.1	27.5	16.50	64.62
5	167.1	30.1	27.5	16.57	13.26
6	165.8	30.1	27.4	.....	65.02
7	165.6	30.1	27.5	.....	13.30
8	164.8	30.0	38.2	.....	13.01

The cooler B.t.u. per minute (Column *D*) represents the heat absorbed in the cooler, computed from the amount of water passing through the cooler and its decrease in temperature.

The total heat discharged to the condenser by the refrigerant (Column *E*) is found by adding to Column *D* the heat equivalent of the net power input to the compressor. This should agree with the heat absorbed by the condenser water (Column *F*) and it is seen that in most cases the agreement is fairly close. In run No. 2 appears the greatest discrepancy, due to the fact that just before this run the air heater by-pass dampers were opened and the air washer, which was cooling the air supplied to the heater, was shut down.

The ratio of the heat discharged to the condenser to the heat equivalent of the total power input is shown in Column *H*. This is usually termed the "Coefficient of Performance." The same coefficient is given in Column *J* for the compressor only, the auxiliary power being omitted.

In test No. 1, when the compressor was operating at the lowest head-pressure (84.4 lb.), we find the largest coefficient for compressor only, i.e., 3.415. However the coefficient for the entire plant for this same test is 1.74, showing the effect of auxiliary power in lowering efficiency. In test No. 5 the cooling tower fan was run at reduced speed, resulting in a lowering of the auxiliary power and a consequent raising of the coefficient of performance to 1.945.

The figures show that operation of the second stage of the cooling tower had little effect on efficiency, although this would probably have a more decided effect in increasing efficiency with a greater load on the system or with a lower outdoor wet-bulb temperature.

Two Heat Units Delivered for One Supplied

The highest coefficient of performance, 1.98, was obtained in test No. 7. Under the conditions of this test heat was absorbed from the outdoor air at a temperature of 48 deg. F., and the air entering the building was heated to a temperature of 74.5 deg. F. Considering these two temperature extremes, the theoretical coefficient of performance for a cycle absorbing heat at 48 deg. F. and discharging it at 74.5 deg. F. is about 20. In other words the actual installation gives a performance about 10 per cent of the theoretical when heat transfer

Table III — Refrigerant Temperature and Pressure

	Compressor — Suction		Compressor — Disch.		Accumulator		Temperature Deg. F.		
Test No.	Lb. per Sq.In. Ga.	Deg. F.	Lb. per Sq.In. Ga.	Deg. F.	Suction Lb. Ga.	Expan. Valve Lb. per Sq.In. Ga.	Gas Out of Cooler	Liquid to Expan. Valve	Liquid from Expan. Valve
1	25.1	42.5	85.4	158.7	26.3	25.4	42.5	84.1	35.1
2	25.0	40.0	94.4	166.6	26.1	24.7	40.9	88.4	35.0
3	25.0	39.3	101.1	176.0	26.0	24.5	40.7	92.2	35.1
4	25.0	39.1	100.5	177.3	26.5	25.5	40.6	94.4	35.5
5	25.0	38.7	99.0	177.4	26.5	25.5	40.0	93.2	35.3
6	24.2	37.5	95.5	178.0	25.2	23.1	38.7	92.4	33.9
7	23.2	36.0	94.9	180.2	24.5	22.5	37.4	90.9	31.9
8	22.5	35.5	94.5	181.3	24.0	22.5	37.0	91.0	31.4

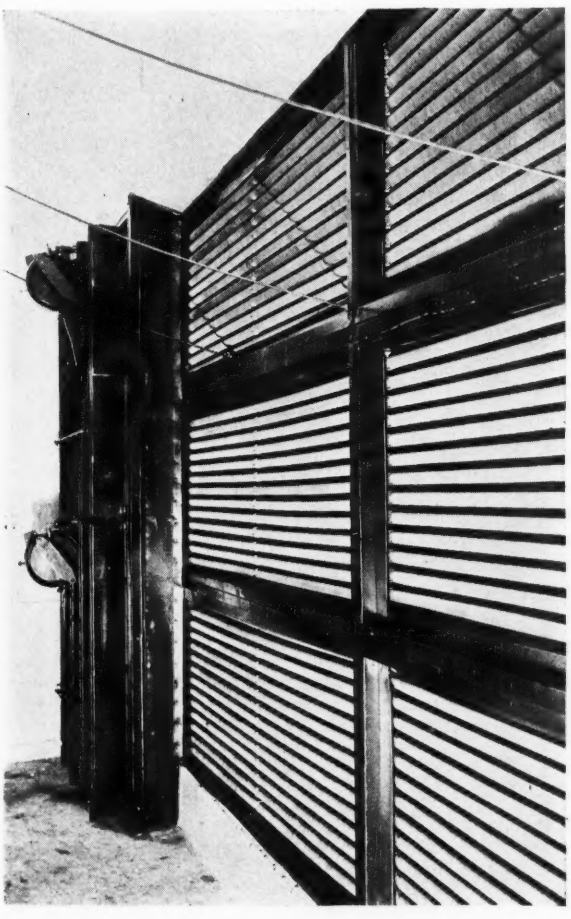
Table IV — Water Temperature and Quantities

Test No.	Cooler Water G.p.m.	Cooler Water Temperature Deg. F. In	Out	Diff.	Condenser Circ. Water G.p.m.	Condenser Circ. Water Temperature Deg. F. In	Out	Diff.	Air Heater Water Temperature Deg. F. In	Out	Diff.
1	417	44.3	39.8	4.5	485	81.0	86.2	5.2	86.1	80.8	5.3
2	418	44.0	39.4	4.6	485	87.9	92.5	4.6	92.0	88.3	3.7
3	418	43.9	39.6	4.3	485	92.2	97.3	5.1	96.8	92.6	4.2
4	418	44.3	39.9	4.4	485	90.6	96.0	5.4	95.8	90.4	5.4
5	418	43.1	38.8	4.3	485	89.2	94.4	5.2	94.2	89.0	5.2
6	418	40.7	36.5	4.2	485	87.9	92.9	5.0	92.8	87.7	5.1
7	418	38.2	34.5	3.7	485	87.3	92.2	4.9	92.0	87.0	5.0
8	753	37.1	34.8	2.3	485	86.7	91.5	4.8	91.4	86.4	5.0

from air to air is considered. However, it would be more fair to the equipment to consider performance on the basis of heat absorbed from the outdoor air and discharged to the condenser circulating water. This is for the reason that the refrigerating equipment is not in any way responsible for the inefficiency of heat transfer from condenser water to the air going to the building.

On this basis, with outdoor air at 48 deg. F. and the condenser water at 92.2 deg. F. as in test No. 7, the theoretical coefficient of performance is found to be 12.5. In this case the plant is giving a performance of nearly 16 per cent of the theoretical. The compressor alone has a coefficient of performance of 2.82, and if we calculate the theoretical coefficient based on the suction and discharge temperatures we obtain 4.4. The compressor, independent of auxiliaries, is therefore giving a performance of 64 per cent of the theoretical.

The figures in the tables show that head pressure on the compressor was constantly rising, due to an increase in the temperature of the condenser circulating water. The result of this was to reduce the coefficient of performance of the compressor, as shown in column *J*. Had it been possible to make a test with the head pressure of Test No. 1 and the auxiliary power of test No. 7, the resultant coefficient of performance for the entire plant would have been 2.32 instead of 1.98. This would, therefore, represent the best performance that could be expected from this plant under the most favorable conditions obtaining during the tests.



Hot condensing water circulates through a fin-tube heater and warms the air for heating the building

Table V — Cooling Tower Data

Test No.	Water Temperature Deg. F. In, 1st Stage	Out 1st Stage	In 2nd Stage	Out 2nd Stage	Air Temperature Deg. F. Inlet D.B.	Inlet W.B.	Outlet D.B.	Outlet W.B.	Fan R.p.m.	Fan C.f.m.
1	39.9	43.0	43.0	43.9	50.6	44.5	42.8	41.6	140	134,000
2	39.4	43.0	43.0	43.6	50.0	44.2	42.7	41.1	140	134,000
3	39.6	42.6	42.6	43.6	50.0	44.0	42.7	41.1	140	134,000
4	40.0	43.0	43.0	44.3	49.5	44.0	43.0	41.6	140	134,000
5	39.3	42.5	42.5	42.8	49.2	44.7	40.6	39.6	58	45,000
6	37.7	40.4	43.6	....	49.4	44.0	43.4	41.3	140	134,000
7	35.3	38.3	....	....	48.1	43.8	40.6	39.9	58	45,000
8	35.0	37.4	....	....	48.0	44.0	38.5	37.9	58	45,000

Shows Large Saving Over Direct Electric Heating

Although the maximum coefficient of performance falls far short of the theoretical, nevertheless the use of the refrigerating equipment for heating has resulted in a definite saving in the Edison Building installation. Here, the heating is not charged with any portion of the cost of the refrigerating equipment, as this was installed primarily for cooling and air conditioning. As the building is electrically heated all heat furnished by the heat pump is supplied at about half the regular rate for electric energy.

▼ ▼ ▼

Using Superheated Steam for Detinning

COMPARATIVELY few people realize that in addition to producing heat and power, superheated steam has a number of other essentially important uses. A new and novel use recently developed is in tinning operations.

Copper wire is removed from its bath of tin and while still hot is passed under a jet of superheated steam. All the excess tin is blown off, leaving only a thin film around the wire. Before the superheaters were installed the detinning was accomplished by drawing the wire through dies or textile wipers which removed the excess tin. However, this was a slower process and gave a product which was subject to relatively large variations in the thickness of tin coating.

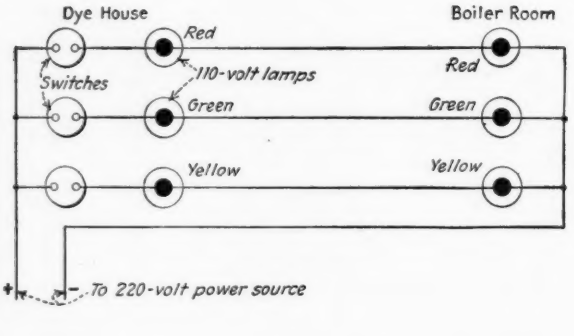
The two separately fired superheaters used for this purpose are capable of raising the temperature of 1,350 lb. of steam per hour 387 deg. to a final temperature of 750 deg. F. and is designed for a maximum pressure of 250 lb. per sq.in.

PRACTICAL AIDS TO OPERATION

Steam Requirements Shown by Signal System

In many industrial plants using large quantities of heating steam it is desirable that the boiler-plant operators have advance notice of large demands for steam. This can be done by a system of signal lights such as that used in our plant. Two fixtures, each containing three ordinary lamp sockets, were made up. Partitions were placed between the lamp sockets and sections were closed by glass windows, one green, another red, and the third yellow.

Ordinary white lights were used in the sockets, and one fixture was placed in the boiler room and the other in the dyehouse in positions where they would be easily visible. Control of the light was provided by three snap switches. The lamps may be wired in series or parallel, but if wired in series as in the diagram, any fault causing one lamp to fail will also prevent the other from lighting. If 220-volt power is available, two 110-volt



lamps may be used in series. The switches were painted red, green and yellow to correspond to the color of the lamps they controlled. A code of signals was prepared in which a yellow light indicated caution or standby; a green light, half load; a red light, full load; a red and a yellow light, morning signal indicating to prepare for load; a green and a yellow light, night signal, notifying the fireman to close down the plant. By means of this simple code a complete understanding of the dyehouse requirements could be transmitted to the fireman, without in any way interfering with the work of the other.

Montevideo, Uruguay. E. Kerr.

Leaky Coils in Oil Tanks

An oil products company in this locality has a large tank into which asphalt is unloaded from railroad tank cars. The boiler plant supplies steam to heat the tank cars and pump the asphalt to and from the storage tanks. A large steam coil is provided inside the asphalt storage tank, and the contents must be heated when supplying the trucks, which are filled from the reservoir. The returns from the heating coil are trapped back to the boiler feed-water system.

The pipe joints in this coil were difficult to keep tight because of the hot asphalt, occasional leaks occurring in spite of all precautions. When a slight leak exists and steam is shut off the asphalt leaks into the steam space. The boiler feed-water system and the inside of the boiler thus were coated with asphalt before the leak was discovered, and a difficult cleaning job resulted.

It was decided to break the line from the coil in the storage tank to the trap and put a tee in it. A close nipple and a gate valve were screwed into this tee and an open blowoff line run from the valve to the ground under the tank. Every time the coil was placed in operation this gate valve was opened for a minute or so until the steam had built up a pressure in the coil and any possible leakage of asphalt was blown out before the returns were passed through the trap. After this change a very small leak was of no consequence, and if a leak at a joint in the coil was large enough to necessitate repair it could be seen by the amount of asphalt blown out of the blowoff valve. Harry Martin.

West Roxbury, Mass.

Oil Cooler Change-Over Shuts Down Low-Pressure Turbine

In a 1,400-lb. central station an incident occurred some time after starting up that nearly caused considerable damage to a turbine. The plant contains boilers supplying 1,400-lb., 750-deg. steam to a high-pressure turbine of 11,800-kw. capacity. Steam exhausts from this turbine through a steam and flue gas reheater before entering the low-pressure turbine. The low-pressure turbine runs condensing and is rated at 43,200 kw.

Steam enters the low-pressure turbine through a valve known as the "intercepting valve." This is a balanced valve held open by oil pressure from the main oil pump acting against a heavy spring in the hydraulic cylinder at the top of the valve. The position of the intercepting valve is controlled by a pilot valve operated by the governor. On one of the rods to the pilot valve floating lever is a handwheel turnbuckle which permits manual control of the intercepting valve by varying the pilot valve setting.

Under normal operating conditions the intercepting valve is kept wide open, but during electrical storms when a trip-out is likely, it is kept slightly closed off so that if the high-pressure turbine should trip the intercepting valve would close in time to prevent the low-pressure turbine from running away and also tripping off. This saved the turbine operator, whose station was at the high-pressure turbine, from having to run across and reset the low-pressure turbine before being able to start up again.

Some time after the plant had been in operation the repair department was changing over from one oil cooler to the other. It had been some time since the second cooler had been used and evidently an air pocket had formed in the oil system. By mistake they opened the

oil valves to the second cooler quickly and the oil pressure immediately dropped too low to hold the intercepting valve open. Immediately, all safety valves opened in the reheat system, but the high-pressure turbine stayed on the line and the low-pressure turbine kept running at synchronous speed, being motorized.

The chief engineer, finding the oil pressure low, opened the throttle of the turbine driven auxiliary oil pump, but forgot the handwheel turnbuckle on the pilot valve rod. The oil pressure built up in several seconds opening the intercepting valve wide and throwing full load on the motorized generator almost instantaneously. Luckily everything stood the shock which must have been severe.

If the handwheel had been turned down closing the intercepting valve the oil pressure could then have been built up, and the handwheel slowly screwed up, allowing the intercepting valve to open slowly and the machine to gradually take the load.

HARRY M. SPRING.

Milford, N. J.

Reducing Power Consumption For Exit Lamps

A TEST was made some time ago in a large office building to determine the possibilities of reducing the cost of exit lights. The lamps used were the standard ten-watt, 120-volt type, colored red. As a result of the study Neon glow lamps were substituted. These are rated at two watts, 120 volts, with a standard base and are also colored red.

There are 50 floors in the building with 4 exit lamps per floor, or a total of $50 \times 4 = 200$ lamps. For the standard ten-watt lamp the power consumption was $200 \times 10 = 2{,}000$ watts per hour, the equivalent of 2 kw.-hr., or 48 kw.-hr. per day. The use of the Neon lamp reduced the power consumption to one-fifth or to $48 \div 5 = 9.6$ kw.-hr. per day. This is a power saving of $(48 - 9.6) \times 365 = 14{,}016$ kw.-hr per year, which at two cents per kilowatt-hour amount to a reduction in power cost of $280.32.

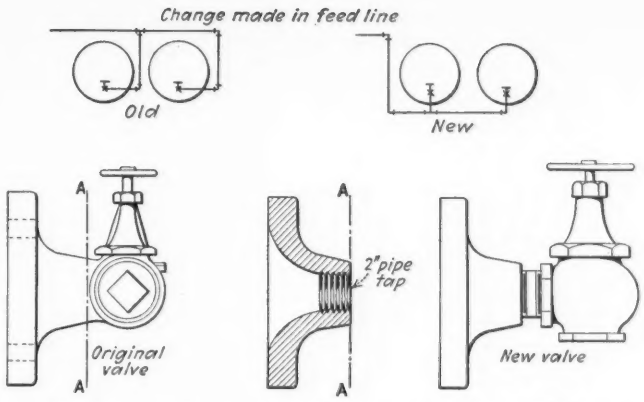
The cost of the Neon two-watt lamps is about three times that for the ten-watt standard lamps, but the life of the former is about three times that of the latter. Therefore, on the basis of cost per lamp hour the two types are about equal, so that the saving in power may be considered clear gain in the use of Neon lamps.

Wayne, N. J. WM. DE VAUGHN.

Stop-Check Combination Valve Made Up of Standard Parts

A SMALL plant recently had experienced much trouble with the combination stop and check valves mounted on the boiler drum head. Stuffing boxes would leak and, due to worn threads, could not be tightened. The flapper had stuck closed on several occasions and had caused one shutdown at a very inconvenient time. Replacement with identical valves would have proved quite expensive, and parts could not be obtained.

What proved to be an inexpensive and satisfactory



Standard parts were used to make this stop-check combination valve

way of retaining the stop-check feature on the drum head was to cut through the nozzle as close to the valve as possible and tap the opening for 2-in. pipe (there being ample metal for this). A 2-in. extra-heavy angle-type non-return valve and nipple were then "made" into a flange. A slight change in the feed line was necessary, but the total cost for four boilers was less than half the cost of valves similar to the originals.

Operating Experiences With Ammonia Compressors

OUR slow-speed horizontal doube-acting ammonia compressor developed a sharp metallic knock when the crank passed the outer dead center. The knock was most severe when starting up in the morning. Compressor clearance was checked and bearings properly adjusted. After the bearings were adjusted the knock did not quiet down, but seemed to increase in sharpness.

During the run one day the noise seemed to increase, and the watch engineer, after shutting down the machine, removed the discharge valve and cage (which on this machine are located on top of the cylinder at the end), and by the aid of a flashlight discovered a mass of metal on the bottom half of the cylinder flattened against the head. Using long thin chisels and scoops, the substance was removed through the cage opening without dismantling the compressor. It proved to be soft metal, about a half pound in weight, that had sluffed off the babbitt bushing and from the metallic rod packing during the reciprocating action of the rod. Falling into the cylinder bit by bit it had been hammered into a solid mass the thickness of the clearance space by the movement of the piston in the cylinder. When the clearance space was filled the additional metal that fell in front of the hardened mass began to transmit the shock to the machine and created a dangerous condition.

The noise was greatest when starting up because the rod was then cold. The rod expanded enough when under running heat to keep the piston from hitting the deposited metal at the head.

In another case, a small two-cylinder vertical medium-speed ammonia compressor motor-driven through a belt, had too great a capacity for the load, so the motor pulley was changed and the machine run at two-thirds its rated speed. Shortly after this change, the wrist pin of the trunk-type piston froze to the rod bushing, and

the pin working in the piston started such a squeal that the machine was quickly shut down. Although caused by lack of lubrication, the reason for this could not be determined at the time. The oil level checked correctly and the wrist pin oiling device was in good order.

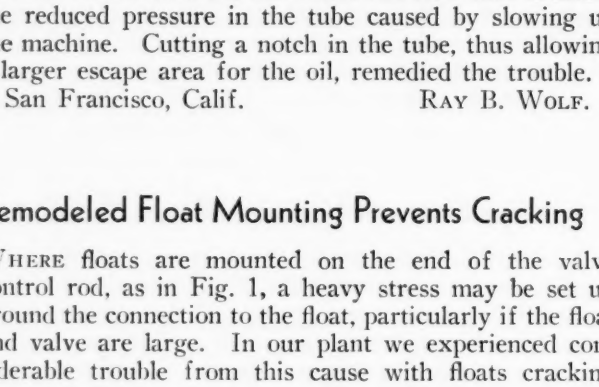
The wrist pin oiler consists of a small ball check, spring loaded, that is attached to the bottom of the crankpin bearing. Dipping into the crankcase oil at every revolution it pumps oil up a small tube fastened alongside the piston rod. The tube curves over the top of the rod and the oil drops into a small reservoir that drains to the wrist-pin oil groove.

A new pin and bushing were installed. After starting the same trouble developed. This time it was discovered that the oil tube was clamped so as to restrict the opening between the tube end and the reservoir bottom to such an extent that the oil would not flow into it under the reduced pressure in the tube caused by slowing up the machine. Cutting a notch in the tube, thus allowing a larger escape area for the oil, remedied the trouble.

San Francisco, Calif. RAY B. WOLF.

Remodeled Float Mounting Prevents Cracking

WHERE floats are mounted on the end of the valve control rod, as in Fig. 1, a heavy stress may be set up around the connection to the float, particularly if the float and valve are large. In our plant we experienced considerable trouble from this cause with floats cracking



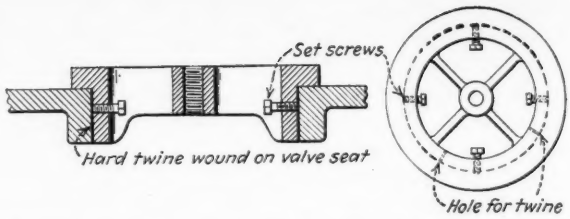
Figs. 1 and 2—Old and new methods of mounting the floats

around their connection. These floats were used to regulate the water level in large tanks. The trouble was overcome by connecting the floats to the valve control rods, as shown in Fig. 2. By lengthening and bending the valve rods so as to increase the travel of the floats it was also possible to reduce the stresses at their connections. Since making these changes no further trouble has been experienced.

Cleveland, O. S. R. STEVENS.

Temporary Repair on Valve Seat Keeps Pump in Service

ONE DAY a plunger pump in our plant showed a large reduction in capacity by failing to maintian a water supply for one of the processes. When the pump was shut down and opened up, the suction valve seat was found with its threads worn away. It was necessary to get the pump into service as soon as possible. To make a permanent repair would require too long, as the parts were not readily available, so a temporary expedient had to be devised.



Section through valve seat, showing how it was held in place by set screws

As shown in the figure, the valve seat was tapped for four set screws. Two small holes that would pass a small hard twine were also drilled through the valve seat, one at the top of the threaded section and another at the bottom. After this was done a layer of hard twine was closely wound over the worn thread of the valve seat, and its ends passed through to the center of the seat and knotted to hold the twine. The seat was then worked down tightly into place on the valve plate and held there by the set screws. The pump was operated with this temporary job for about one month and gave satisfactory service until arrangements could be made to complete a permanent repair.

Detroit, Mich. R. K. MURPHY.

CURRENT COMMENT

Blowdown System Competes with Heaters

THE FUEL saving obtainable by a continuous blowdown system may be overestimated if the effect on the feedheater system is not considered. In many plants the extraction cycle is used in direct competition with the bleeder heaters. As the saying is, "It's not all gravy."

Assume a plant where the blowdown of 2,040 lb. per hr. at 469 deg. F. leaves the boiler and passes through a heat exchanger where the 11,430 lb. of 70-deg. makeup is heated to a temperature of 139 deg. This makeup is introduced just ahead of the No. 1 heater, which heats the condensate to 139 deg. The heat recovered from the blowdown is 2,040 (437 — 50) = 790,000 B.t.u. per hr., which can be credited to the blowdown equipment.

If the blowdown heat exchanger were left out and the blowdown sent to the sewer, the makeup would be heated in the extraction heater from 70 to 139 deg. F. by 827 lb. of bleed steam. This 827 lb. is saved from the condenser, and a condenser loss of 924 B.t.u. per lb. is thereby recovered. This is a total of 765,000 B.t.u. which must be considered as a debit against the blowdown exchanger, leaving a net of only 790,000 — 765,000 = 25,000 B.t.u. per hr., or a little over 3 per cent of the apparent saving.

Saving at the boiler end opens the spigot at the condenser. The condenser loss can be recovered with equipment already installed while the boiler losses need additional equipment.

I am not trying to disparage the blowdown heat recovery equipment. It has and fills a very definite place

in the power plant. I do, however, want to point out the fact that often in power-plant design one piece of equipment is in almost direct competition with the other and that too much care cannot be exercised in selecting the combinations of equipment used not only for heat but for monetary economy. P. F. ROGERS.

Brooklyn, N. Y.

Space is lacking to include the other portions of Mr. Rogers' letter discussing the effect of blowdown heat recovery on turbine output and the results obtained if the blowdown heat is returned to the system after the first heater.—EDITOR.

Electric Heat Less Costly Than Appears

THE WRITER'S interest has been aroused by your reply (page 598, *Power*, April 19) to a question on the comparative cost of heating by electricity and coal, the electric rate being 3c. per kw.-hr.

It would seem to the writer, after some experience in this particular field of electric heating, that some issue can be taken with correctness of the comparative costs as stated in your answer to this question. There is no doubt, of course, of the fact that electricity is a very refined form of energy and that only 3,415 B.t.u. are initially available in a kilowatt of energy. The writer feels, however, that your figure of 13,500-B.t.u. coal is higher than the usual run of coal purchased for residential use and that the correct figure is more likely to be between 9,000 and 11,000 B.t.u. per lb.

It has been the writer's experience that in computing the total quantity of heat available at the radiator valve as compared with total B.t.u. in the coal originally fired under the heating boiler, that only 25 to 30 per cent is actually available for heating at the radiator.

The losses of course are due to boiler inefficiency, maintenance of draft, piping losses, necessity of maintaining a rekindling charge in the furnace, and a certain small percentage of unaccounted losses. Moreover, with coal heat is released as the fuel is burned, whereas the electric current can be easily stopped and started when the exact heating requirements have been met. The writer's experience indicates that a 3c. electric rate is comparable to coal at $25 to $30 per ton.

LOUIS T. M. RALSTON.

New York City

Blowoff Connection

IN THE June 7 number, R. E. S. asked at what point in a cross-drum boiler the connection for continuous blowdown should be made. My suggestion is that the blowoff line should be in the drum, preferably an inch above the fusible plug. In case of trouble the danger of draining your boiler is then minimized.

Take, for instance, a boiler being banked and the fireman neglecting to close the blowoff. With a blowoff in the bottom of the boiler it would soon become dry. With the blowoff attached to the drum, on the other hand, steam would start through the line after the water had dropped below the opening. While, no doubt, this would eventually drain the boiler, it would take much longer to do so. The same theory applies to a break in the line. THOS. A. WALSH.

Watertown, Mass.

Don't Reclaim Babbitt

IN *Power* for June 14, L. R. Baker advises D. L. B. that remelting old babbitt is good practice. In the original question, D. L. B. states that the babbitt to be remelted contains chips of iron, steel and cast bronze. If for no other reason than this fact, the babbitt should not be reclaimed for use in an important bearing, as a single tiny steel chip on the face of the lining will cut the shaft as "quick as a wink." Whatever saving might be made by using the reclaimed babbitt, will be lost a hundred times over by the damage done.

As to drawing out these little chips with a magnet, that is not feasible if the job is to be a thorough one. There is no certainty that all of the steel is drawn out and the danger is ever present.

Aside from this, if the bearing is at all important, reclaimed babbitt should never be used. It has been definitely established that with every melting, babbitt loses some of its virility. Furthermore, with every melting there is an oxidation which changes the formula. This is evidenced by the fact that the dross from a genuine babbitt analyzes to a higher tin content than the babbitt itself.

But even disregarding the danger of a bit of steel left in the babbitt, or a change in the formula, it would be the utmost folly to use reclaimed babbitt in times when, like the present, the price of babbitt is so exceedingly low. The labor cost involved, however little it may be, will undoubtedly bring the cost of the reclaimed as high as, and quite probably higher than, the cost of the new babbitt less the money you may get for selling the old babbitt at what it will bring. A. HOYT LEVY.

Brooklyn, N. Y.

Babbitt or Anti-Friction Metal?

IN MR. EMERSON'S article on rebabbitting Diesel engine bearings (*Power*, June 14), he evidently has had a mixture of babbitt and anti-friction metal, which I have never heard anybody recommend for soldering. In this case, his mixture is purely a mechanical one, and should be well stirred. A yellow or brown coating indicates the formation of lead oxide, as both tin and antimony oxides are white.

While many metals alloy in different proportions, there are certain definite proportions which correspond to multiples of their respective atomic or molecular weights. Thus in a true babbitt, ten parts of tin to one each of antimony and copper will analyze: tin (Sn) 86.5 per cent, antimony (Sb) 8.9 per cent and copper 4.6 per cent. In anti-friction metal, as antimony is added to lead the hardness increases and the melting point decreases until the antimony content reaches about 17 per cent. Then if more antimony is added, it segregates in tiny masses independent of the lead, and the melting point rises. The maximum hardness seems to be reached in proportion of 3 to 1 (atomically), which would give the proportions of 83.8 per cent for lead and 16.2 for antimony. This neutral combination is known as a eutectic, which really means "low melting point," and while it cannot be reached exactly, the nearer we aim at a mark, the more likely we are to hit in its neighborhood. L. R. BAKER.

St. Louis, Mo.

Several recent improvements, results of research laboratory investigations, have contributed to better brush, commutator and collector-ring performance. They have made it easier to achieve sparkless operation—the aim of engineers who design or operate electrical machinery

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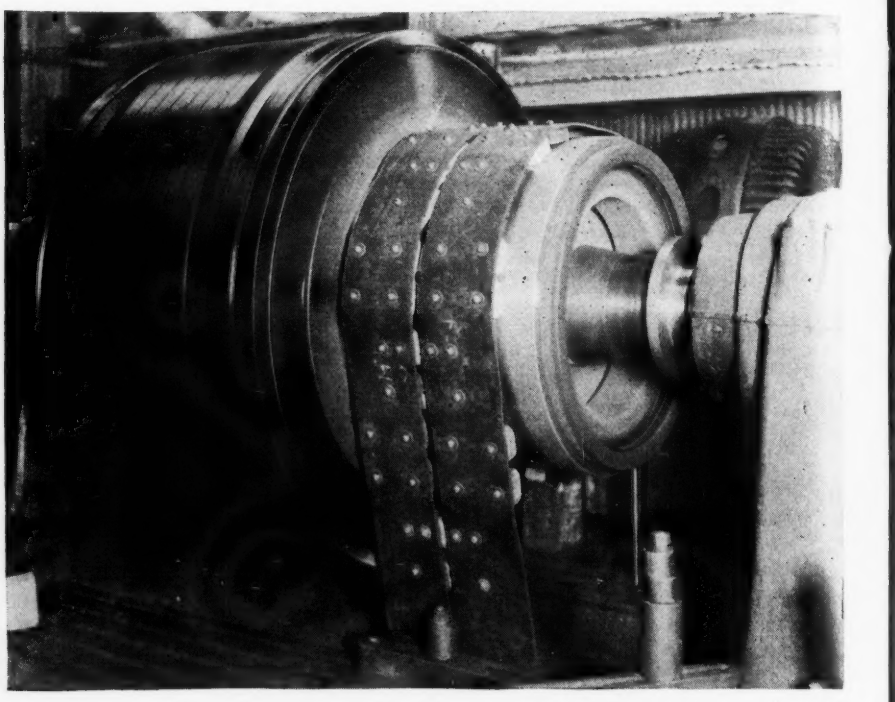


Fig. 1—Seasoning a commutator by the friction of wooden blocks

Better Operation of COMMUTATORS and COLLECTOR-RINGS*

IT HAS been shown experimentally that current is conducted from a brush to a movable ring or commutator by a small number of minute points on the brush face that are actually in contact with the movable conductor. These minute points are continually being worn and burned away and are being replaced by others in different parts of the contact surface. Existence of these spots has been proved by discharging a heavy current from a condenser across the brush contact for an extremely short time. These spots cannot be seen at the surface of a brush that has operated for some time and has a good fit and polished surface until the condenser discharge test has made their location visible, Fig. 2.

"Brush glowing," a phenomenon sometimes experienced on commutating machines, is caused by one spot of the brush becoming heated to incandescence, thus raising to a red glow the surrounding brush material. A bit of copper picked up on the brush face may lower the contact drop at that particular point and start the glowing. The glowing may also be caused by the surface condition of the commutator.

Once this has started, the negative temperature coefficient of a brush tends to accentuate the trouble. The localized heating causes an expansion of the brush at that point, raising the rest of the brush away from intimate contact with the commutator, thus increasing the pressure and current density of the glowing area.

After a few seconds, this high portion of the brush will be worn and burned away. The rest of the brush then returns to more intimate contact with the commutator surface, carries some of the current and relieves the glowing spot, which thereupon disappears or travels to some other portion of the brush.

Glowing is often accompanied by "streamers" from the brush. These are small particles of brush material that have been subjected to a high current and heated to incandescence and are thrown off by mechanical rotation of the commutator. Fig. 3 shows the face of a brush that has been subjected to glowing and throwing off of streamers.

If measurements are made of the current carried by various brushes operating in parallel on the same arm of a commutating machine, or the same ring of a collector, it is often found that one brush may be carrying most of the current. This same unequal division of current also occurs among the various brush arms in parallel on a commutating machine.

It has also been found that the amount of current carried by any brush varies. One brush may be carrying several times its share of the current at one instant, a little later the conditions may be reversed and some other brush may be overloaded, while the first brush is underloaded. This is due to brush surface condition and the number of contact spots that at any given instant are carrying the current.

In the case of commutating machines, it is possible to change the division of current between various brush arms in parallel by increasing the pressure on the brushes of an arm that is carrying less than its share of current. In extreme cases, the brushes on one arm may carry from 5 to 25 times as much current as those of some other arm in parallel with it.

It is possible to cause a better division of current between various brushes in parallel on the same arm by using high-resistance shunt leads from the brushes to the arm. Since the load current must go through these shunts, a considerable loss will be entailed, which is undesirable from the efficiency standpoint. This scheme has only been tried in a few cases.

It was found several years ago that an air pressure of 2 to 5 oz. per sq.in. exists under a brush on a movable ring. This pressure, it was found, could be reduced by cutting transverse slots in the ring or brushes, or by drilling radial holes in the brushes. The voltage drop between brush and ring was reduced, giving better operation and a more even division of current among brushes operating in parallel on a given ring. A few converter collector rings were slotted at that time, but the use of slotted rings was abandoned commercially. The slots would fill with dirt and brush material and, being trans-

*Abstract of a paper presented, by C. Lynn, designing engineer, Westinghouse Electric and Manufacturing Company, before the Chicago Section of the Association of Iron and Steel Electrical Engineers.

verse, were quite difficult to get clean.

To overcome the cause of these troubles, the Westinghouse research department suggested a low-pitch spiral grooving of commutators and collector rings, so that during a part of each revolution some of the brush surface would be entirely relieved of contact with the moving conductor. The groove moves comparatively slowly in a direction parallel to the shaft under any given portion of a brush. This permits that portion of the brush to cool appreciably before it again has to carry current when an ungrooved portion comes in contact with it. The circumferential groove, besides giving a cooling effect, relieves the air pressure under the brushes just as transverse grooves do.

Fig. 4 shows a type of helical groove in two slip rings. The width of the groove, the ratio of grooved to ungrooved width and the pitch of the grooves can be varied over a considerable range without appreciably affecting the results. Ordinarily a groove $\frac{1}{8}$-in. wide, with $\frac{1}{4}$- or $\frac{1}{2}$-in. pitch, gives satisfactory results. Grooving the rings increases the current density on that portion of the brush that is momentarily carrying current, but when rotating, the groove continually moves over the brush contact and prevents any one spot from carrying a heavy current continuously.

The grooves are generally made approximately $\frac{1}{8}$-in. deep, although they can be made any depth desired. Air in these grooves helps cool the current-collecting parts and reduces the temperature of the parts in actual operation.

Some 13,000-amp. synchronous converters have been in operation for about 2 yr. with grooved collector rings. The results to date on these machines show a much more uniform brush wear than is obtained on other duplicate units using smooth rings. Tests on these machines also show that with slotted rings the brush pressure can be reduced, thus helping to decrease brush friction and wear.

Grooving of collector rings carrying direct current on synchronous machines has also been used with good results, overcoming in some cases conditions of sparking and rapid wear of brushes.

Fewer commutators have been grooved than collector rings. In the case of some medium-size industrial motors, grooving the commutator has permitted an increase in overload swings on these motors. Some street railway motor commutators were grooved to eliminate burned and flat spots previously experienced. Grooving of large commutators has not been done because these applications are still in the experimental stage.

To measure brush and commutator performance without subjecting the machines to an operating test, the brush-drop oscillograph test and roughness-factor meter were developed by the Westinghouse company. The former consists simply of taking an oscillograph record of the voltage drop between a stationary brush and a movable conductor, such as collector rings or commutator. The roughness-factor meter, gives the average comparative roughness of a commutator, while the oscillogram indicates the comparative roughness of each individual commutator bar.

Since a commutator has to go through a temperature cycle with corresponding changes in stresses, it is possible to determine its performance by taking brush-drop measurements with the commutator at various temperatures. These can be secured even with a commutator not connected to an armature by heating with friction of wooden blocks rubbing on its surface while rotating, as indicated in Fig. 1. These blocks are fastened to belts, the ends of which are clamped against the floor with any tension desired to give a sufficient pressure for heating the commutator bars by friction. The brushes ride on the commutator where it is not subjected to the force of the blocks. By changing the pressure on the wooden blocks, variations in the temperature at which brush drop tests are measured can be secured, and roughness factors can be measured at any temperature desired throughout an operating cycle.

This method of heating approximates load operating conditions in that the bars are individually heated at their surface and the commutator subjected to all the stresses due to rotation and expansion forces of heating. Many hundreds of tests made in this manner on commutators have shown that the test is an accurate one, and that a commutator that gives a roughness factor below a value that has been found to be satisfactory will give successful performance in service.

Brush holders have ordinarily not been given the importance that they deserve in the current collection problem. They have a very large influence on the roughness factor obtained because this factor depends upon how intimately the brush makes contact with the commutator. Brushes that move around in the holders and chatter on the commutator cannot operate satisfactorily.

Experience proves that it is ordinarily better to operate brushes inclined rather than radial to the commutator surface, as they are less subject to chattering. Opinion differs as to whether brushes should run inclined against or with rotation, but the prevailing opinion seems to favor inclination against the direction of rotation, especially for high commutator surface speeds, as there is less tendency for them to bind in holders.

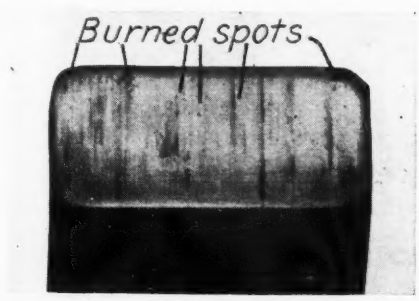


Fig. 2 — Spots burned on a brush's face by current from a condenser

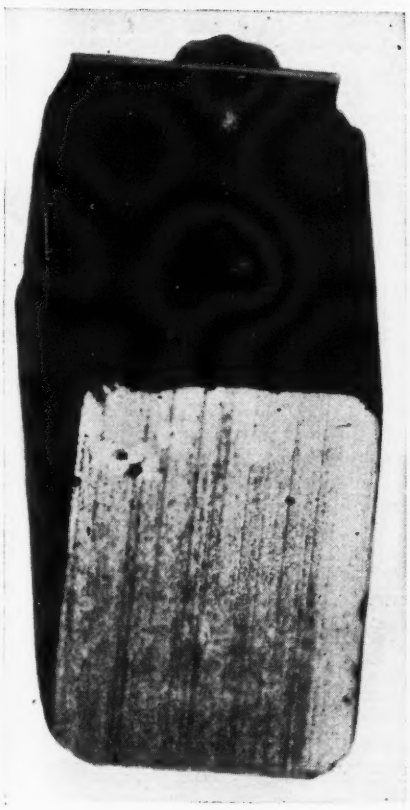
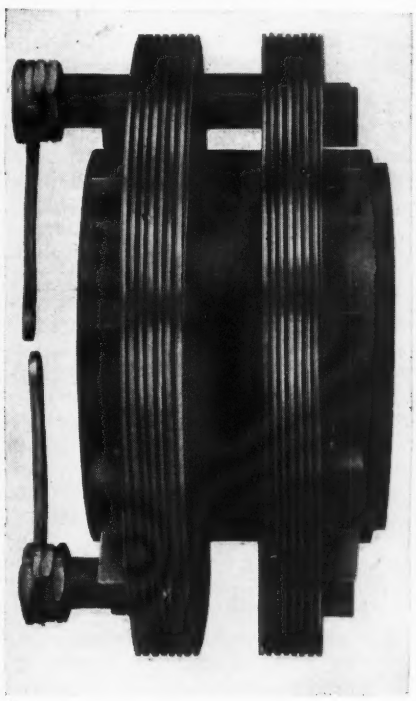


Fig. 3 (Lower left)—Face of brush that has been glowing

Fig. 4—Spirally grooved slip rings for a 15,000-kva. synchronous condenser



Central Station Plant and Performance

A Review of the Latest American Practice

By A. G. CHRISTIE

Professor of Mechanical Engineering
Johns Hopkins University

Submitted by the American Committee of the International Electrical Congress, Paris, July 4 to 19, 1932, Professor Christie's paper, here presented in abridged form, is part of a much longer paper. Co-authors and their subjects (not here covered) are Alex. D. Bailey (Economics of Electric Power Supply), F. A. Allner (Factors Affecting Hydro-Electric Development) and F. C. Hanker (Trend of Output and Voltage in Large Generators)

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STEAM pressures in recent American central stations are in the range of 450, 600, or 1,200 lb. per sq.in. Temperatures vary from 700 to 825 deg. F., with one plant at 850 deg. Plants with 1,200-lb. pressure have operated satisfactorily, and the expected economies have been realized. One builder offers turbines for 1,200 lb. and 1,000 deg. with no reheat. The trend is toward higher pressures and temperatures.

Steam Generating Units

Cross-drum horizontal, two-drum vertical, Stirling, and other types of water-tube boilers are in service. The use of single-pass boilers is increasing, since these cost less, permit simpler boiler plant, carry higher ratings and have lower draft losses than multi-pass units. A few boilers with welded drums are in service.

The trend is toward the use of units of great capacity, both in amount of heating surface and in steam output. A boiler (see drawing) at the East River Station, New York, contains 60,706 sq.ft. of water heating surface and has produced 1,250,000 lb. of steam per hr. Maximum tube length is 36 ft.

High-pressure plants have proved reliable. In 1931, the 1,300-lb. section of Lakeside Station, Milwaukee, had availability factors over 90 per cent for both boilers and turbines. The high efficiency of large steam generators is maintained over a wide range of load. Large-output boilers appear to be the most economical units to install in a new plant.

Both convection and radiant superheaters and reheaters are in use. Combinations of convection and radiant surfaces give almost constant steam temperatures at all boiler loads.

Boiler-water conditioning, especially at high pressures, is receiving much attention. The maintenance of proper sulphate-alkalinity ratios has overcome caustic embrittlement. Foaming and priming at high ratings, when boiler water concentration is high, cause impurities to be carried over to the turbine. Such scale deposits, provided they are soluble in water, may be removed by washing with wet steam while the turbine is in service. The problem of washing is growing in importance and may ultimately become a major consideration in plant operation.

Steaming economizers are used with high-temperature feed water. Air heaters serve, with or without economizers, to provide air temperatures in the neighborhood of 350 deg. for stokers and 400 to 650 deg. for pulverized coal.

Water-cooled furnace walls with exposed tubes, fin tubes or tubes faced with bare or refractory-coated cast-iron blocks, are installed under nearly all large-output boilers with either stokers or pulverized coal.

Usually motor-driven centrifugal pumps furnish feed water to boilers, with a steam-driven unit for reserve or emergency service. Quick starting is an important characteristic of feed pumps. Motor-driven multiple-plunger feed pumps will be installed in a new 1,200-lb. plant where their over-all efficiency of 77 per cent at full load is sufficient justification for their higher cost and greater floor space requirements.

Furnace Equipment

The projected area, fuel-burning capacity, and efficiency of underfeed stokers have been greatly increased. A recent stoker installation (Hudson Avenue) will burn 73 lb. per sq.ft. per hr. on 694 sq.ft. at a heat liberation in the furnace of 51,000 B.t.u. per cu.ft. per hr. Zoned air control, improved pusher mechanism, better tuyeres, water-cooled side walls, deeper ash pits and more rugged clinker grinders characterize the newer units. Heat liberation rates vary from 20,000 to 80,000 B.t.u. per hr. per cu.ft. of furnace volumes with stokers.

Forced-draft, chain-grate stokers are used for free-burning coals, lignites and anthracite. The largest chain grate has 528 sq.ft. of surface, burns 65 lb. of coal per sq.ft. per hr. at maximum output and has a furnace heat release of 42,000 B.t.u. per cu.ft. per hour.

The unit system of pulverized coal firing is gaining in favor, as it provides a cheaper and simpler plant than the central system. Unit mills up to 50 tons per hr. capacity are in operation. Burners are still being improved. Those of the turbulent mixing type give better combustion and require smaller furnaces than the earlier long-flame burners. Systems of boiler control provide instant response to changes in steam demand. Coal is now dried in the pulverizers by preheated air. Vent discharges are delivered to the furnace, thus eliminating former dust nuisances.

Many new boilers under which coal with low-fusing ash is burned are provided with furnaces having vertical coal firing, and with water-cooled refractory-lined bottoms on which the ash accumulates as liquid slag and from which it is tapped-off in liquid form.

Many forms of dust catchers, precipitators, and gas washers to remove both ash and undesirable gases are under development to clean chimney discharges, but the problems of cleaning flue gases are by no means completely solved.

Steam Turbines

Sixty-cycle turbines operate at 3,600 and 1,800 r.p.m., with a few at 1,200 r.p.m. The capacity of a given casing is limited by the allowable length of the last blades and by permissible leaving losses. A maximum tip speed of 1,200 ft. per sec. has been reached, and in certain cases, leaving losses have amounted to 7 per cent of the adiabatic heat drop. Single-cylinder units of 80,000-kw. and tandem units of 160,000-kw. capacity, all at 1,800 r.p.m., are in operation. The largest single-cylinder condensing unit at 3,600 r.p.m. is rated at 10,000 kw., while tandem condensing units of 15,000-kw. capacity are installed at this speed.

Difficulty has been experienced with erosion by moisture in the last rows of blades due to insufficient superheat for the range of expansion. Heavy round-edged blade sections are used in place of the earlier feather-edged blades.

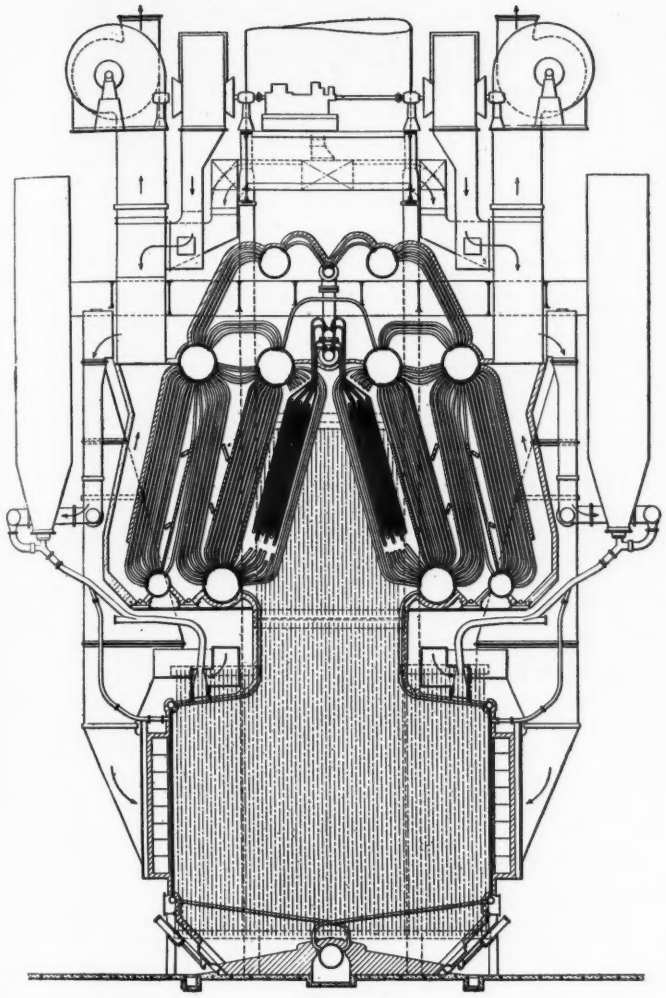
The Detroit Edison Co.'s turbine of 10,000-kw. capacity, with initial conditions of 375 lb. and 1,000 deg. F., has operated satisfactorily at this temperature. Its performance will in all probability lead to a substantial increase in initial steam temperatures for new power plants.

Closed bleeder heaters are generally used, but jet heaters are increasing in number. Evaporators to furnish distilled make-up water form part of the bleeder feed-heating system. Deaeration is generally effected in one of the bleeder heaters.

Condensers

A vacuum of 29 in. is specified and secured where cooling water of 55 deg. F. or less is available for the greater portion of the year. In southern plants with 70-deg. water, 28½-in. vacuum must suffice.

Four trends characterize recent condenser practice. Better distribution of cooling surface has increased its effectiveness and lessened the pressure drop



The largest steam generating unit in the world, one of the boilers in East River Station, New York Edison Co., New York. Boiler heating surface, 60,706 sq. ft. Maximum rating 1,250,000 lb. of steam per hour

through the tube bank. Undercooling of the condensate is prevented by introducing exhaust steam into the hot well. Leakage of cooling water into the condensate has been practically eliminated by rolling both ends of the tubes into the tube sheets, which may be floating or fixed. Effective sub-cooling of the air pump suction has increased the available vacuum.

The use of welded-plate construction for the condenser shell is increasing, as this decreases weight and first cost. Steam-jet vacuum pumps are almost universally used.

Considerable study has been devoted to the design of piping and valves for high pressures and temperatures and to researches on the flexibility of such pipe systems. Various forms of welded joints for high pressures, such as the Sarlun and the Sargol, and other joints with gaskets of different metals, are in satisfactory use.

The creep rates and properties of alloys for high temperatures are being investigated in several laboratories, and satisfactory materials for use at 1,000 deg. F. will soon be available.

All water, air, gas, oil and low-pressure steam piping is now welded.

Station Performance

The first cost of steam stations per kilowatt of capacity has been decreasing steadily during the past few years and will continue to decrease with the more extended use of both turbines and boilers of large capacity. The cost per kilowatt for stations with steam conditions of 1,200 lb. and 800 deg., does not appear to be $5.00 per kw. greater than the unit cost of stations for 450 lb. and 750 deg. The decrease in fuel consumption of late years in American central stations has been remarkable. From 1919 to 1931 the average coal consumption per kw.-hr. dropped from 3.2 to 1.56 lb.

Means for Reducing Power Costs

The cost of power consists principally of fixed charges upon the investment in plant, and of operating and maintenance expenses. Plant investment can be reduced as noted above. If higher pressures and temperatures are employed, fuel costs can be reduced. Unit combinations of one boiler and one turbine will simplify piping and auxiliary arrangements and, by permitting full automatic operation, will lower operating costs.

Many turbines are now purchased with most economical load at 60 per cent of rating. This allows a margin for peak load and emergency demands.

Attention is being directed to the possibilities of reconditioning and increasing the capacities of old stations. These can often carry the low load-factor portion of the demand at least total cost. Frequently this reconditioning provides added system capacity at less cost than can be secured by any other means.

The elimination of the power-house structure to lower first cost of plant is under consideration. Two out-of-doors plants are being constructed, one with the boilers unhoused, and the other with the turbines outside. The elimination of superstructure may not offer as great an opportunity for cost reduction as simplification of design.

TABLE COMPARATIVE OPERATING CONDITION OF MERCURY VAPOR PLANTS

	Hartford	Kearny	Schenectady
Load on mercury turbine, kw.	10,000	20,000	20,000
Speed of mercury turbine.	720	900	900
Total steam from unit, lb. per hr.	129,000	325,000	325,000
Steam pressure, lb. gage	275	365	400
Steam temperature, deg. F	680	750	760
Mercury vapor pressure at turbine, lb. gage	70.7	125	125
Mercury vapor temperature at turbine, deg. F.	884.5	958	958
Absolute pressure of mercury condenser, in. of Hg.	1.5	3.0	3.0
Temperature of mercury vacuum, deg. F.	440	485	485

Binary Vapor Plants

Diphenyl oxide is being circulated through economizers in one of the newer stations and serves to preheat air entering the furnace. It is proposed to use diphenyl oxide in a new station both to superheat the high-pressure steam and to reheat it between cylinders.

A mercury boiler and turbine have operated successfully in series with a steam turbine at one of the plants of the Hartford Electric Light Co.

This plant delivered power to the switchboard for a year at an average fuel consumption of 10,250 B.t.u. per kw.-hr.

Two mercury plants of 20,000 kw. are under construction. One at Schenectady, N. Y., will deliver power to the N. Y. Power and Light Co. and will send 325,000 lb. of steam per hr. to the works of the General Electric Co.

The other, at Kearny Station of the Public Service Electric and Gas Co. of N. J., will deliver steam to turbines in which 33,000 kw. will be generated, thus making, with the 20,000 kw. from the mercury turbine, a total output of 53,000 kw. for the combined mercury-steam unit. The accompanying table gives details of the three plants.

The mercury vapor plant appears to be economically justified on a system where fuel costs are high or where the unit, with its accompanying steam turbine, can be given a constant heavy loading through the year.

General Trend of Development

American central station plant is still undergoing change and development to increase reliability, simplicity and efficiency. While much has been achieved, many improvements can still be made. Higher operating pressures and temperatures are now recognized as practical and economically justified. The present trend is toward the production of more kilowatt hours from every dollar of total expense.

Causes and Effects of Cavitation in Hydraulic Turbines

ARRANGEMENTS have been made by a prominent utility company whereby Professor Spannhake will be able to conduct extensive experiments on cavitation at the Massachusetts Institute of Technology, the results to be published later. With the developments of high-specific-speed propeller turbines and centrifugal pumps, cavitation becomes a limiting factor affecting design for maximum capacity, and causes considerable damage to runners. It is, therefore, essential that the fundamental principles be understood and the phenomenon so controlled that large pumps and turbines can be operated satisfactorily without pitting.

The coefficient *sigma* offers an approximate measure of the elements conducive to cavitation, but there is need of more critical study of other influences in order that the results of laboratory tests may be correctly translated to apply with certainty to the prototype. Studies indicate three methods of avoiding cavitation: first, by design of turbines to operate with forward whirl in the draft tube, second, by improved distribution of pressure along the back side of the blades, and third, by the adoption of a blade profile that will have its forward edge shaped more advantageously.

Prof. Spannhake, when speaking before the N.E.L.A. Hydraulic-Power Committee, said in part:

"It was over 35 years ago that cavitation in high-pressure turbines was first experienced, and engineers have had many troubles in reducing it, especially for ships with high-speed propellers driven by steam turbines. I remember in particular two characteristic experiences. About 1899, at Jaice electric power plant, Bosnia, the high-pressure turbine showed destructive effects on the back or low-pressure sides of the blades. On a German torpedo boat at the time when turbine drive was first introduced, after a 3-hr. full-speed trip, the three blades of the propeller showed the effect of cavitation as in Fig. 1. This occurred on the 'pushing' side of the blades.

"In 1918, I tried to investigate this problem by tests in a small glass-covered box in which a blade about like an airplane profile was mounted, Fig. 2. The blade was to simulate the entrance flow into the blading of a turbine, and a destructive effect was experienced even on the glass covering a part of the box. All these effects looked like fatigue of the material caused by very high pressures that gave the surface the appearance of lava.

Practically the entire range of human knowledge and research to date on cavitation has been covered in a paper by Prof. Wilhelm Spannhake of the Technische Hochschule, Karlsruhe, Baden, Germany. He is now visiting professor of hydraulics at Massachusetts Institute of Technology, and presented his paper before the Hydraulic Power Committee's Spring Meeting of the National Electric Light Association. A short abstract is given on these two pages, but his discussion has been published complete as a 20-page report by the Association. Copies may be obtained from the Association offices in the Graybar Bldg., New York City, for 35 cents by members, 50 cents by others

"Cavitation is now recognized as a consideration which imposes a limit in the working capacity of turbines. But, the theory of high-speed turbines and practical considerations, together with experimental knowledge, prove that in order to get good efficiency from such power generating equipment it is necessary to operate just as nearly as possible to the velocities and pressures which cause cavitation. It is, therefore, important to solve this problem, to seek out its real nature and to find some means for controlling it.

Nature of Cavitation

"In any flow, closed or open, if a cavity or void filled with air, gases and fluid vapor is formed, then we have cavitation. Pure water can stand tension. On occasions water has been subjected to a tension of over 20 atmospheres. This is possible only if there is no air or other foreign matter in the water. Turbines are run with water containing solid matter and at least some air and gases. In this case when the pressure at a point drops to a certain value, coherence of the water is broken, and air, oxygen and other gases are liberated. Bubbles are generated that assist in starting vaporization of the water. Also the solid bodies can have this catalytic effect. In any case, if the pressure is sufficiently low, the quantity of air in the bubbles is generally small compared with the water vapor.

"Theoretical considerations and experience show that if there are no vortices in the fluid, the point of lowest pressure can occur only on the boundaries of flow, that is, on the solid walls, no matter whether these walls are standing or moving in the fluid. Where there are vortices, the lowest pressures—as far as the neighborhood of the vortices is concerned—are generated in their centers. These voids can become very much drawn out, and the center of a vortex filled with air can extend either down stream or even across the flow. I remember a very beautiful effect which appeared during an experiment with a weir in the flume which was tested at the hydraulic lab-

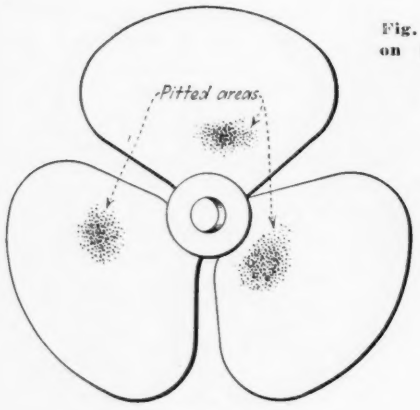


Fig. 1—Pitted spots on torpedo-boat propellor

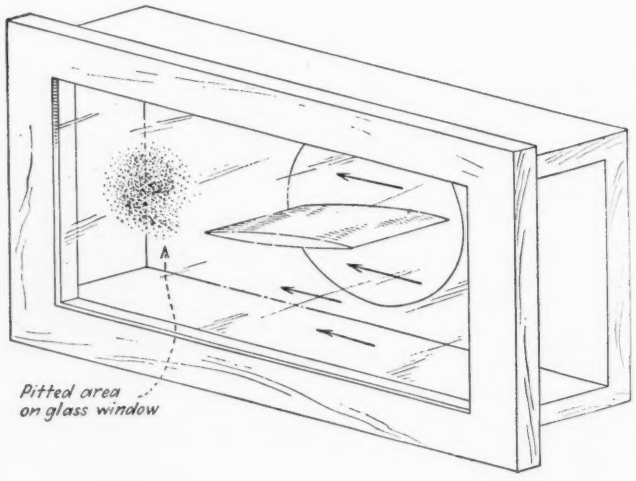


Fig. 2—Pitting on glass window of apparatus designed to study cavitation

oratory in the Karlsruhe Technical University. The weir was formed as in Fig. 3, with water entering the weir box near the bottom at one side, so that there was in the forebay above the weir a distinct roll. Therefore, a certain amount of rotary velocity was in the flow as it approached the weir crest.

Free Vortex in Draft Tubes

"A similar case of potential cavitation occurs in the majority of turbines and pumps, if there are peripheral components in the flow, as often happens. It is not possible to have purely axial flow in draft tubes. I think it is this phenomenon that sometimes causes oscillation in output when a unit is on the line, and in its speed when running idle before being synchronized, because the conditions generating the whirl in the draft tube are periodically changing. It seems that this is quite a good explanation. The conditions in such a case were much improved by putting radial fins in the draft-tube liner, as in Fig. 4. Following the modification, the intensity of rotating motion was altered, and the vortex was so changed that the amplitude of the oscillation in output and speed was decreased, while on the other hand, the rapidity of fluctuation was increased. In this case such a free vortex does not damage the material of the casing, but, under other conditions, free vortices can have a very bad effect.

"In Kaplan turbines, the guide vanes are sometimes arranged to overhang the curb ring, leaving a small space below the vanes when they are in the open position. The end elevation of the guide vane is a rectangle, and a phenomenon occurs which is similar to that called Karman vortex street. These eddies, Fig. 5, while in the region where the pressure is high, do no harm. If now the vortex extends into a region of low average pressure, then the local pressure drops to the vapor pressure of the fluid and a void is generated. This void with the eddy then passes over the wall of the casing, and if it comes again into a higher pressure, it suddenly collapses. This collapse is a damaging shock to the wall. Experience shows that on the wall, after it is subjected to such punishment, there are a number of spots, each indicating a damaged condition, the number of spots being equal to the number of guide vanes.

"If at any point the absolute pressure approaches vapor pressure, air and gases are liberated from the water and a small bubble is formed. Into this bubble the vapor of the fluid is added as the vapor pressure is reached, making it larger. Now, either the bubble is shifted downstream as a whole, or else it expands so much that one end of it reaches again a zone of higher pressure. Then the fluid vapor is suddenly condensed, since the process of vaporization and condensation is readily reversible, but the reabsorption of air does not take place as readily. The bubble surface to which the air is exposed is so small that in the short time required for the vapor fluid to condense, the gas cannot go back into the fluid and be dissolved again. This small bubble of air is, therefore, compressed by the impact of the collapse in an infinitesimally short time. Furthermore, the volume itself being so small, the ratio between the volume after compression and that before the beginning of this effect is very high, so that tremendously high pressures result. Rather rough approximations have shown that it is possible to create about a thousand atmospheres.

"Another important thing is that this small bubble of gas, when so compressed, can enter a small crevice in the material. If the bubble happens to strike and lodge in such a crevice, it can act like an explosive and be destructive, especially in the corners. The effect is dangerous, and is the real reason for the rapid breaking up of material by cavitation.

"All other effects are secondary. Physical and chemical effects are, in my opinion, of minor importance in this case, even though they may be important in others, especially if the water contains certain gases such as carbon dioxide. Nevertheless all the rapid destruction mentioned before in the case of the high-pressure turbines, or the high-speed propeller, are the result of a mechanical, or hammering effect. This hammering acts not only in the direction normal to the surface, but there is also a tangential, or scouring effect, which breaks down the material very rapidly because the bubble is moving with the flow when it collapses.

"It is not possible as yet to offer an exact theory for all these phenomena because they are very complicated. The effect may produce great turbulence, aggravated by the generation of cavities. The destruction depends on the elasticity of the materials and of the water itself, and on the yield point of the materials. Materials having the higher resiliency like bronze are supposed to stand this effect better than those that are brittle like glass. Much depends also on the heat conductivity of the material and the water. The compression of this small amount of gas or air, having so small a surface, and in so short a time, is a process that is certainly not isothermal, but is either adiabatic or polytropic. Thus an increase of temperature is possible. And that probably explains this curious looking effect on the damaged surface that makes it look like lava."

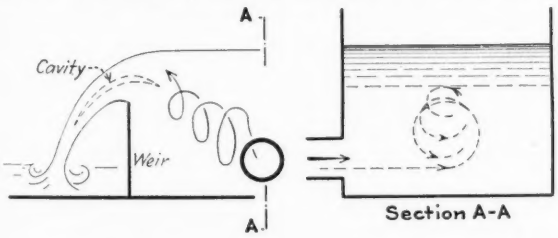
After discussing the effects of Reynolds number or cavitation test results obtained from a model and full-size turbine, Prof. Spannhake showed that the conditions conducive to cavitation can be expressed by the simple formula for the coefficient *sigma*, which is:

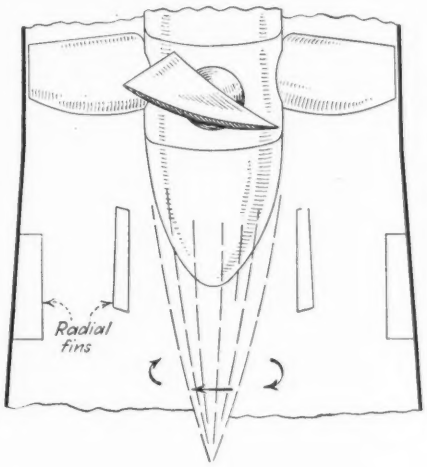
$$\Sigma = \frac{H_b - H_v - H_s}{H_t}$$

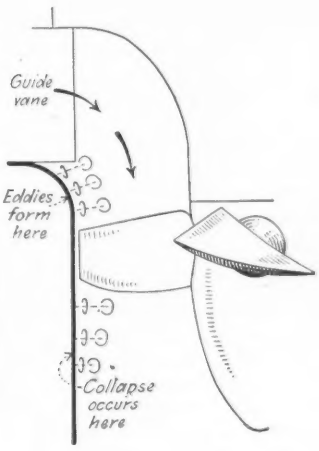
Where H_b = the atmospheric pressure
H_v = the vapor pressure
H_s = the static suction head
and H_t = the total head

The theoretical basis of this formula is given in a curve and diagram which shows the progressive changes in pressure on a particle of water while flowing through a turbine. It is shown that the pressure on the particle increases as it passes down the penstock and enters the scroll case, where the pressure begins to decrease due to an increase in velocity. In passing through the turbine runner, the pressure may become so low on the back of the blades that caviation begins.

Fig. 3 (below)—Cavity in nappe of a weir, resulting from circulation of water in the forebay. Fig. 4 (right)—Radial fins to modify vortex in draft tube Fig. 5 (far right)—Vortices formed by guide vanes







READERS' PROBLEMS

EVAPORATING WITH SUPERHEATED STEAM.—*We have a vacuum pan evaporating 300 gal. per hour. The steam chests will not stand more than 5 lb. pressure. The problem is that we are short of low-pressure exhaust steam and in some way we have to use steam at 80 to 90 lb. pressure gage.*

If we use a reducing valve the steam will be superheated when bringing it down to 5 lb. How much superheat will it have and how can it be desuperheated? What diameter pipe line would be required to carry a steam flow of, say, 4,000 lb. of steam an hour at 5 lb. pressure? K.F.

The superheat resulting from the throttling you propose should be too little to cause any trouble. First, consider the amount. From the Mollier chart it is seen that throttling dry saturated steam from 90 lb. gage to 5 lb. results in 65 deg. of superheat. Since this represents only about 3 per cent of the heat given up to the vacuum pan the superheat will disappear almost as soon as the steam enters the tubes. This superheat will have little affect, one way or the other, on heat transfer, judging by comparable tests with water evaporators.

While it appears, then, that desuperheating is unnecessary, this can easily be accomplished by various thermostatically-controlled spray devices on the market.

The size of the pipe line depends upon its length. It would seem reasonable to run the high-pressure pipe line to the present low-pressure line rather than to extend the low-pressure line. This will save piping cost, and give a steadier process pressure. The chart on page 15 of this number will be found of assistance in determining the pipe size required.

GAS ENGINE MIXTURE ADJUSTMENT—*How should gas mixtures be adjusted on a 4-cycle gas engine? Can greater efficiencies be obtained by adjusting, and if so, how can I do it?* T.E.L.

The usual method is to adjust the mixing valve until the engine seems to be running nicely. This is, however, open to all sorts of errors. It is better to get a gas meter of some sort, put it in the line, then test at a series of loadings, say 25, 50, 75 and 100 per cent, each time adjusting the valve so that gas consumption is at a minimum for the particular load. You can then set the valve at the best point for your particular range of loading.

An illustration of the impracticability of hit-or-miss setting was brought out in a recent paper. The authors had a shop mechanic set the mixing valve at what he thought was the proper loading. Their test showed gas consumption to be 11.7 cu.ft. per bhp.-hr. (at a 40-hp. load) while the minimum was 9.5 and the maximum was 14.5. Thus gas consumption could be varied as much as 5 cu.ft. per bhp.-hr. with the engine running, to all appearances, satisfactorily.

PUMP AND PISTON DISPLACEMENT DEFINED—*What is meant by pump displacement and piston displacement, and how are they determined?* C.S.

Piston displacement is the volume swept through in one stroke of the piston and is equal to the cross-section area of the piston or plunger multiplied by the length of the stroke, expressed in cubic feet or cubic inches. The displacement of piston and plunger pumps is frequently expressed in gallons and is the number of gallons discharged at one stroke without slippage of the pump. It is equal to the cross-sectional area of the piston or plunger in square inches times the length of the stroke in inches, divided by 231. Assume a pump with a plunger 10 in. in diameter and a 12-in. stroke, then the pump's displacement in gallons is equal to $10 \times 10 \times 0.7854 \times 12 \div 231 = 4.08$.

METAL WEDGES USED IN INDUCTION MOTOR SLOTS—*To hold the coils in the starter slots of induction motors why are metal wedges sometimes used instead of wood or fiber?* C.P.D.

An induction motor with partly closed stator slots, other conditions being equal, will have a better power factor than one designed with open slots. On the other hand, open-slot cores are easier to insulate and coil installation is easier than in partly closed slots. To gain the advantages of the two types of slots, metal wedges, frequently called magnetic wedges, are used in open slots. One form of these wedges is two pieces of steel held against the sides of the slot by a center brass piece. The wedges are insulated from the core to avoid short-circuiting the teeth.

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Alignment of Chain Drives Checked by Different Methods

Several ways of aligning chain-drive sprockets are suggested, along with rules of installation practices that insure satisfactory operation

WE HAVE a number of chain drives in our plant, some being of the so-called silent type and others of the roller type. To obtain the best service from these drives it is necessary that they be properly lined up and maintained in that condition. The best way of checking their alignment is a problem that I do not feel we have solved to the best advantage, and I would appreciate hearing from Power *readers how they do this work in their plants.* E.D.C.

High-Speed Chain is Replaced by Belt

SEE that the speed of the chain is not sufficient to throw the lubricant off by centrifugal force. At a plant where chain drives were used in reducing from 1,800 r.p.m. to $\frac{1}{4}$ r.p.m. the first two drives were identical, 6-in. driving and 36-in. driven sprockets. Theoretically, the faster chain had only one-sixth the load of the slower, but would whip itself to pieces in a few weeks, while the other gave excellent service for four years, 24 hours a day. Although the chain speed was only 2,800 ft. per min., it was impossible to keep this chain lubricated, hence the excessive wear. I replaced the high-speed chain with a belt in each of nine units, retaining the chains for the lower speeds.

St. Louis, Mo. L. R. BAKER.

Aligns Chain Drives With Straight-Edge

I ASSUME that the inquirer has, as have most of us, experienced most trouble through faulty alignment of short-center drives, as with a motor or sliding base. With this type drive on short centers up to 3 ft., my experience has proven that it is more satisfactory to use a steel straight-edge against the side of the sprockets to check their alignment. With longer centers between sprockets frequently found on heavy equipment, I used piano wire in a similar way to lining up pulleys and shafting. The wire should be fixed independently of the drive and driven shafts and measurements taken at two diametrically opposite points on driver and driven sprockets. When all four dimensions are equal, the alignment is correct.

As the majority of silent-chain drives are generally designed for use in a horizontal or nearly horizontal plane, it will not be necessary, if sufficient care

is taken in checking the drive, to remove the bottom half of the chain casing before checking the alignment. On heavy silent-chain drives it is best to make a rough check before final alignment is made to obtain the correct length of chain. M. S. DUNN.
Cleveland, O.

Aligns Chain With Two Long Pins

TO ALIGN chain drives, remove two pins from the links at points approximately on top of the driving and driven sprockets. Insert a pin in each hole with a cross-section corresponding to that of the pins removed and long enough to project about 9 in. on each side of the chain. Caliper or gage the distances between the ends of the pins on each side of chain and adjust centers until these are identical. This will give alignment in one plane. Place the eye on a level with one of the pins and adjust the other until the two are parallel. This will complete the alignment. DAVID LOW.
New York City.

Uses Piano Wire to Align the Sprockets

TO CHECK alignment of either a silent, a block or a roller-chain drive, the shafts must first be parallel and level. This can be checked by measuring the distance between the shafts with a tape or trammel and leveling with a graduated spirit shaft level. The sprockets must be centered exactly, which can be checked by stretching a piano wire parallel to the plane of one sprocket correctly located and bringing the second sprocket to the same distance from the wire. After the shafting has been leveled, this second check is sufficient to prove that sprockets are aligned correctly.

It is assumed that shafting, supports and chain drives are correctly designed. Horizontal chain drives need no adjustment after proper installation. However, vertical drives are not to be recommended but if necessary, suitable adjustable center sprockets are advisable and would need periodic inspection.
Tonawanda, N. Y. M. R. WARDEN.

Wear on Chain Guide Links Shows Misalignment

THE IMPRESSION I get from E.D.C.'s question is that he has trouble in maintaining alignment of the chain drives. If this be so then the answer to the question is to improve the stability of the drives. In the operation of fifteen silent chains ranging in capacity from 2 to 25 hp., only one has given us alignment trouble. This developed after a change of motors and was due to difficulty in holding the motor in a fixed position on its base.

Starting with a stable installation, an inspection of the guide links of the chain from time to time will show whether the drive remains in alignment. Misalignment will result in wear on the sides of guide links and of the grooves in the sprockets. A cord can easily be held parallel with the end of the smaller sprocket, then note how it lines up with the larger one. If necessary, alignment of the two shafts can be checked by measuring the distances between them. Where this is not possible, a base line can be provided parallel to the fixed shaft and the movable one aligned to it. To provide for taking up slack in the chain with wear, adjustment should be made by two takeup screws if possible so that each can be turned an equal amount, thus preserving alignment at all times. G. E. LEAVITT, JR.
Bayonne, N. J.

A Question for Our Readers

The water used to cool the crank-case oil in our uniflow engines amounts to about 290,000 cu.ft. per year. The make-up water required by our boilers is about 72,500 cu.ft. per year. Our CO_2 recorder requires about 21,000 cu.ft. of water per year. Water for these three purposes all comes from the same source.

We have two uniflow engines and two oil coolers. Why not pipe the discharge from these two oil coolers into a header, and pass this water to our boilers by way of our water softener and feedwater heater and pumps, taking a tap off for the CO_2 meter supply between the oil coolers and the softener?

Could we not install a thermostatic valve to release some water to the sewer in case the softener and CO_2 meter did not take enough water to cool the crank-case oil? In this case the thermostatic element could be located in the discharge from the oil cooler.

It will be noted that the water required by the CO_2 meter and boilers totals about 93,000 cu.ft. per year, which is considerably less than the water required by the oil coolers.

Suitable answers from readers will be paid for if space permits their publication. Typewritten replies should preferably be double-spaced.

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Gives Ten Rules for Obtaining Satisfactory Chain Service

THE FOLLOWING precautions are always taken in the application of chain drives in our plant, where we have a great many of both silent and roller types that have given entire satisfaction:

(1) The driving and driven shaft bearings are always supported by sole plates on massive concrete foundations or by a rigidly welded or riveted-steel framework.
(2) The sprockets are turned on the edge of the beads so as to run true. Some engineers consider this unnecessary, but it is a great help in aligning the sprockets.
(3) The sprockets are aligned by a fish line, which is stretched on both sides of the bead so as to compensate for any variation in widths.
(4) The shaft center lines are separated as much as possible without causing the chain to be taut at any point of its travel. It is advisable to turn the shafts by hand to check the latter.
(5) The pulling strand of the chain is arranged to be on the bottom if this is possible.
(6) After alignment is completed, the shaft bearing boxes are dowelled to the sole plates or the steel frame.
(7) The set screws that hold the sprockets from slipping endwise on the shaft are then spotted into the shaft by countersinking the spot that the former made on the latter.
(8) If possible the faced hub of the sprockets is made to act as a shafting collar next to the bearing. Otherwise two collars are used, one on each side of the bearings. These collars also have their set screws spotted.
(9) An oil-tight welded steel—about 16-gage—guard is placed over every drive and sufficient oil poured in to keep the chain well lubricated while running.
(10) The inspection panel in the guard is opened periodically and every part of the chain inspected for wear and loose rivets.

By insisting on these ten rules being followed the writer has had practically trouble-free operation on these drives. A couple of drives were tried once without constant lubrication, but a few weeks' run indicated that trouble would develop if an oil bath was not added.

When a chain gets badly worn it is never replaced without also replacing the sprockets at the same time. Worn sprockets and a new chain are simply potential grief. We have run fairly high-speed roller chains that had become worn so much by years of service that the two strands rubbed in the middle of the drive, yet they give no trouble. The oil bath must never be allowed to become dirty and gritty. It pays to change oil in a chain drive just as in the crank case of your automobile. The oil can be put through a good filter and used again. GEO. P. PEARCE.
Moline, Ill.

German Power Technique Advances in Face of Depression

Power's German correspondent reports important discoveries of power research laboratories

IN THE face of an unprecedented economic depression, which has greatly affected power production and the manufacture of power equipment, the technique of power generation is still being steadi'y advanced by the work of German engineers and scientists. On the one hand, the output of water-tube boilers (stationary installations) in 1931 was only 16.1 per cent of 1927; on the other many manufacturers still maintain in full swing the work of their industrial laboratories.

Their output of knowledge is revealed in the accompanying bibliography, which many American power specialists will be able to use. In the following report, numbers given in parentheses refer to the corresponding numbers in the bibliography.

"Coal Beds" of Salt Lumps

In the German combustion field the traveling grate remains supreme, because it has been found best suited for the burning of the nation's many varieties of coal at best efficiency. The type is being further developed. Even the competition of pulverized coal is met by traveling grates and other stokers that can build up load 100 per cent in the fraction of a minute. The record was held by a zoned traveling grate, where only 15 sec. was required to increase the evaporation from 6 to 12 lb. of steam per sq.ft. per hour (1, 2, 3 and 4). Such research results will cut investment and operating costs and reduce the need for accumulators.

To liberate more heat per cubic foot of furnace volume and thus reduce first cost, engineers are systematically investigating ignition and combustion. Rosin & Kayser have compared the dissolution of burning layers of coal lumps in the combustion air with the wasting away in water of lumps of salt of the same shape and packing. From actual experiments with salt (5) they found the best shapes and kinds of layers of fuel, and the best way to apply the air.

Similarly, Werkmeister & Schwiedessen (6 & 7) worked out relations between the amount of coal burned and the progress of combustion (burning time). Their findings will serve boiler designers.

Several investigations of the mechanism of ignition (8, 9 & 10) are to be published in the near future. Ash is being studied, particularly by Rosin (11). Several publications of the Powered Fuel and Combustion Committee of the Reichskohlenrat (National Coal Council) discuss quick ash (12 & 13), how it may be separated from coal and the costs.

Pulverized fuel is looking up, because designers have succeeded in burning efficiently larger and larger grains (14), and because coal grinding plants are being continually improved.

Engineering materials are being improved to give increased resistance to molten ash and to raise endurance limits.

Human Factor Eliminated in Welding

During the past year welding technique has reached the point of reliability where welding has become an essential feature in German boiler construction. Existing rules and regulations dampen progress somewhat, but the welding industry has developed an arc welding method that meets all demands for thick-walled boiler drums. "Mechanical seaming," as it is called, assures absolute independence of the welder's skill. Governmental supervisors have allowed for seams so welded a strength 0.9 that of the solid plate, if all welded seams are annealed above the transformation point.

Measure Speed of Water Circulation

Following the work of several investigators, a survey of the problem of water circulation has been published (15). This tells how, practically, to measure the speed of circulation in water-tube boilers. To predict circulation speed in advance, further study is needed.

Independent research in the field of heat economy and combustion is maintained by the Verein Deutscher Ingenieure (Institute of German Engineers), the competent Powdered Fuel & Combustion Committee of the Reichskohlenrat, several of the Boiler Inspectors' Associations, and the Association for Boiler Operation & Smoke Abatement at Hamburg.

In this connection a new piece of standardization should be noted, namely the compilation of standards and definitions regarding furnaces and boilers. This is jointly sponsored and published by the Verein Deutscher Ingenieure and the Powdered Fuel and Combustion Committee of the Reichskohlenrat (16).

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(1) "Elastizität von Steinkohlenfeuerungen" (Flexibility of bituminous coal furnaces) by Fr. Schulte and H. Presser in *Feuerungstechnische Berichte** (1931) Nr. 7.

(2) "Elastizitätsversuche an Braunkohlenstaubkesseln" (Flexibility tests on boilers fired by powdered lignite) by P. Rosin, E. Rammler, and H. Stimmel in *Feuerungstechnische Berichte** (1931) Nr. 7.

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(4) "Verdampfungs- und Elastizitätsversuche an Braunkohlenrostfeuerungen" (Steaming and flexibility test on lignite-fired grates) by P. Rosin, E. Rammler, and J. H. Kauffmann in *Feuerungstechnische Berichte** (1930) Nr. 4.

(5) "Zur Physik der Verbrennung fester Brennstoffe" (On the physics of the combustion of solid fuels) by P. Rosin and H. G. Kayser in *Feuerungstechnische Berichte** (1932) Nr. 8.

(6) "Verbrennungsverlauf bei Steinkohlen mittlerer Korngrössen" (The process of the combustion of medium sized bituminous coal grains) by H. Werkmeister in *Feuerungstechnische Berichte** (1931) Nr. 8.

(7) "Versuche über die Verbrennungsvorgänge in einer Kohlenstaubflamme" (Tests on the process of combustion within a powdered-coal flame) by H. Schwiedessen in *Feuerungstechnische Berichte** (1932) Nr. 8.

(8) "Zündung von Kohlenstaub in der Schwebe" (Inflammation of powdered fuel in suspension) by W. Litterscheidt.

(9) "Die Zündung fester Brennstoffe auf dem Rost" (Inflammation of solid fuels on the grate) by P. Rosin, R. Fehling, and H. G. Kayser.

(10) "Durchzündung der Brennstoffschicht" (Ignition of the fuel layer) by P. Rosin and E. Rammler. Nr. 8-10 to be published in Nr. 10 of the *Feuerungstechnische Berichte**) and in *Archiv für Wärmewirtschaft und Dampfkesselwesen.*

(11) "Das Ascheproblem in der Feuhrung," (The problem of ashes in furnaces) by P. Rosin in *Braunkohle* (1931),

(12) "22. Berichtsfolge des Kohlenstaubausschusses des Reichskohlenrates" (22nd Series of Reports of the National Coal Council).

(13) "27. Berichtsfolge des Kohlenstaubausschusses des Reichskohlenrates" (27th Series of Reports of the National Coal Council).

(14) "Erfahrungen aus dem Kesselbetrieb im Grosskraftwerk Böhlen (Experiences gained during boiler operation at the Böhlen super-power-station). By Zeuner in *Feuerungstechnische Berichte** (1931) Nr. 6.

(15) "Neuere Arbeiten über den Wasserumlauf in Wasserrohrkesseln" (Recent research regarding water circulation in water-tube boilers) by R. Boese in *Archiv für Wärmewirtschaft und Dampfkesselwesen* (1932) Nr. 4.

(16) "Kenngrössen und Begriffsbestimmungen für Feuerungen und Dampfkessel" (Standards and definitions regarding furnaces and boilers) in *Archiv für Wärmewirtschaft und Dampfkesselwesen* (1931) Nr. 12.

*Issued by the Reichskohlenrat.

Four Countries Contribute to A.S.M.E. Power Program

Steam turbine practice in Great Britain and in the United States, British high-speed oil engines, economic balance between steam and hydro capacity, hydraulic practice in Europe, hydro-electric development in Canada and other subjects of interest to hydro-and-steam power-plant engineers formed an important part of the A.S.M.E. semi-annual meeting program

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BIGWIN INN, Lake of Bays, about 150 miles north of Toronto, Ont., was headquarters for the semi-annual meeting of the American Society of Mechanical Engineers, June 27 to July 1. Through the co-operation of the Ontario Section, host for the meeting, the Engineering Institute of Canada and the Institution of Mechanical Engineers of Great Britain, papers were presented that reflected engineering practice in Great Britain and Canada. Other excellent papers dealt with power engineering progress in the United States, and a paper on pump research was contributed from Germany. As a result, the meeting had very much of an international flavor.

British Steam-Turbine Design

In reviewing British practice in steam turbine design, F. W. Gardner, Newcastle-on-Tyne, England, drew attention to the influence that England's national electricity developments have had upon turbine design. Since the electricity commissioners were appointed the size of turbine units in England has increased from 25,000 to units of 50,000- to 75,000-kw. capacity. For these large machines, single-shaft designs are favored, and multi-cylinder machines are general for both impulse and reaction turbines. Up to the present, single-shaft units of 40,000 kw. and upward have all been designed for 1,500 r.p.m. Several 30,000-kw. machines at 3,000 r.p.m., with double-flow low-pressure elements are in operation.

For the larger central-stations now under construction there appears to be a definite preference for pressures of 600 to 650 lb. per sq.in. The generally accepted steam temperature is 800 to 850 deg. at the turbine throttle.

In discussing the design of turbines for these high temperatures, it was stated that for cylinder castings and shaft forgings the stress must not exceed a value which will produce a creep of 10^{-8} in. per inch per hr., a rate which would produce a strain of 0.05 in. in a 5-ft. length in ten years. The excellent performance of steels containing 0.5 to one per cent of molybdenum have resulted in their being generally regarded as the most suitable material for both castings and forgings that have to operate at temperatures above 800 deg.

In discussing the detailed design of turbine parts, Mr. Gardner disclosed that all rotor forgings are bored and chambered where possible, and are examined by means of a borescope. Before final finishing the rotors are run at a speed 1½ times the working speed. When the steel portion of the turbine cylinder is made in two sections, with a transverse joint between them, this joint is held by heavy countersunk rivets and is welded all around on the inside.

The problem of preventing blade erosion at the high tip speeds now employed has divided itself into two parts, that of eliminating as much moisture as possible from the lower stages, and that of obtaining erosion-resistant material. A simple system of drainage can be made to remove an appreciable quantity of moisture. High-speed tool steels appropriately treated were said to possess the highest resistance to erosion, and have been found to be most suitable for blade protection.

The practice of providing large machines with motor-driven turning gears is now becoming general. These are generally designed to produce a rolling speed of 1'5 r.p.m.

In discussing design trends, it was disclosed that one English turbine manufacturer has designed a double-deck compound unit. Built-up rotors are being designed in an effort to reduce stresses encountered at high rotational speeds. The introduction of hollow blades has been suggested as a means of reducing their weight and thereby reducing the decrease load on turbine disks. The development of various self-contained types of turbine units has proceeded rapidly, and has now become general for units up to 3,000-kw. capacity.

Steam-turbine plant practices in the United States were comprehensively covered in a paper by Vern E. Alden and W. H. Balcke, an extensive abstract of which was published in June 28 number, page 949.

Steam-Turbine Discussion

A. G. Christie, when discussing the steam-turbine papers, called attention to the large 3,000-r.p.m. tandem units that have been developed in England. The largest 3,600-r.p.m. tandem unit in America is rated at 15,000 kw. The British, however, have several 30,000-kw. units operating at 3,000 r.p.m. and can build machines up to 50,000-kw. at that speed. American engineers have favored single-cylinder units at 1,800 r.p.m., although some efficiency may be sacrificed by their use.

It was pointed out that American steam practice favors 1,200-lb. pressure instead of 600-lb. for reheating plants, some American engineers holding that the 1,200-lb. plant can be built for the same cost as the 600-lb. station. Data in a recent N.E.L.A. report showed that the average performance of 1,200-lb. stations over a range of capacity factors is about 8 per cent better than 600-lb. plants, compared to 5 per cent allowed by Mr. Gardner in his paper.

Mr. Christie said that steam reheating only effected a thermal gain of about two per cent over no reheating. Reheating, however, reduces the moisture content at the exhaust and this is a practical benefit of considerable value. The per cent moisture at the last row of blades in American turbines may be as high as 14 per cent, whereas abroad this is often limited to 10 per cent. The greatest difficulty is experienced with blading with tip speed of 1,000 ft. per sec. and above. Parson's blading with relatively lower steam velocities has been more subject to erosion than impulse blading, suggesting that supersaturation was less pronounced in the Parsons than in the impulse blades. Devices to drain off moisture have been only partly effective due to the nature of its formation and the path of the water droplets. Experimental work at Johns Hopkins University indicates that no separating device can be very effective.

British High-Speed Oil Engines

J. L. Chaloner, consulting engineer of London, England, sketched the development of British high-speed oil engines during the past 25 years. Mr. Chaloner expressed as his opinion that "more coordination, more pooling of experience and more standardization, national or even international, is bound to react favorably on the position which the high-speed oil-engine industry holds." He considers this fairly easy of accomplishment.

Much of his tabulated and classified-material on British engines will prove of interest and value to American diesel designers.

In reviewing the extent to which the high-speed type has been applied as an industrial power unit, Mr. Chaloner has this to say: "When considering power-generating units, the power-station engineer has always associated increasing size of unit with decreasing costs per horsepower for capital expenditure, fuel, and maintenance. The same benefits do not apply in the case of oil engines irrespective of their speed. It always warrants, therefore, consideration being given to the merits of several medium-sized engines in place of one large one.

"The generation of power by oil engines has received a setback in Great Britain through the introduction of interconnecting power lines. A number of important oil-engine-driven stations have become merely distribution centers, taking their supplies from the nearest

superpower steam station. As a result, the application of the high-speed engine has become restricted, and available performance figures are correspondingly limited.

"In a high-speed engine the wearing surfaces are much harder, lubrication is efficient, and alignment is good. The wear and tear, and with it the maintenance, should therefore be in every way satisfactory. The author has for some time now used a maintenance factor for comparing the various makes. This factor is a function of the piston velocity and brake mean effective pressure, and 2,500 is a fair maximum value for normal working conditions."

Steam and Hydro Economics

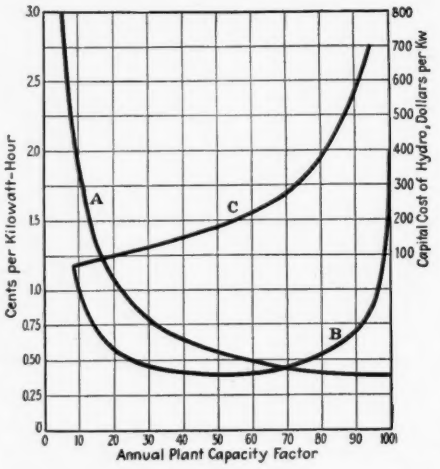
There is a popular fallacy that hydro-electric developments and steam plants are competitive sources of power. K. M. Irwin and Joel D. Justin in a paper "Economic Balance between Steam and Hydro Capacity," pointed out that each proposed hydro development should not be measured against an equivalent steam installation as a sole source of power, but that it is necessary to forecast the characteristics of the particular system in which additional capacity is required and to determine for the conditions whether additional hydro or steam will give the lowest cost power supply for the system.

The economic balance between steam and hydro capacity for a given system at any given time, it was pointed out, depends on the shape and size of load curve; availability of suitable hydro sites, additional transmission facilities required; runoff and its seasonal distribution; availability and cost of storage; cost of fuel; and availability of condensing water. It is evident that the economic hydro ratio may vary from zero in sections where hydro sites are extremely expensive and fuel cheap, up to 100 per cent where fuel is expensive and hydro sites are available with large well-regulated stream flows.

The downward trend of steam plant operating costs and the improved efficiency of the plants during the last 20 years has been an outstanding factor in creating the idea that hydro can no longer compete with steam. While favorable conditions for steam plants have been developing, changes have been taking place that have greatly improved the economic functions of hydro plants on power systems. In the past many hydro plants were constructed as the sole source of power supply for a community. Under such conditions it was necessary that the minimum flow of the river should be sufficient at all times of maximum power demand to supply the load. Except where seasonal storage was available this resulted in a large waste of water that could not be used when the stream flow was above minimum. In such plants the investment in land dams and riparian rights is necessarily high compared with the investment in power house.

In a large modern power system containing steam and hydro plants it is frequently economically possible to increase the capacity of hydro plants to ten or more times that required to utilize the minimum flow of the river. Under these conditions the cost per unit capacity installed, that is, the incremental cost, will be greatly reduced. As such a plant can replace an equal amount of steam capacity on the system it should be, in the authors' opinion, treated as supplying firm capacity.

The effects of the low incremental cost of hydro installations in determining the use to be made of a hydro project may be better understood by considering the curves in the figure. Curve *A* gives the total cost per kilowatt-hour for power supplied by a modern highly efficient steam plant. Curve *C* shows the total capital cost per kilowatt of installed capacity in a hydro plant, at various annual capacity factors. This plant is fairly typical on a representative American river with ample pondage for weekly regulation.



Total cost of energy at various capacity factors of steam and hydro plants

Curve *A*—Cost per kilowatt-hour from a steam plant with average cost of $95 per kw. Fixed charges taken at 12 per cent, 7 per cent money; coal $4.00 per net ton in the bunker; annual fixed charges $11.40 per kw.; annual fixed operating cost $3.75 per kw. Variable production cost $0.002 per kw.-hr. Curve *B*—Total cost of energy from hydro plant having capital cost indicated by curve *C*. Total annual cost equals 10 per cent of capital cost.

This curve indicates the tremendous variation in unit capital cost of hydro according to the capacity installed. For example, if the project were planned on a 90 per cent annual capacity factor basis the capital cost would be about $580 per kw., whereas for a 20-per cent annual capacity factor the cost would be about $100 per kilowatt.

Curve *B* shows the total cost of power from a hydro plant having capital costs indicated by curve *C*. This curve indicates the very high cost of hydro power compared to steam at high capacity factors and its relatively low cost compared to steam at low capacity factors. At 70 per cent capacity factor the cost of steam and hydro power is the same. While there are many situations in which, if curves similar to those shown were plotted, the results would be quite different from those shown, nevertheless it is the author's opinion that they are fairly typical for any locations.

"Hydro-Electric Development in Canada" is the title of a paper by Dr. T. H. Hogg in which he reviewed the progress made in water-power utilization in Canada and the attitude toward governmental supervision in the various parts of that country.

The growth of water-power developments in Canada has been rapid. From a total installed capacity of less than 200,000 hp. in 1900 it reached 6,660,000 hp. by the end of last year. As with other natural resources, control of water-power developments rests with the provincial government.

European Hydraulic Practice

Features of European hydraulic practices that differ from those in American were given in a paper by Prof. Robert W. Angus. A number of the low-head plants using Kaplan turbines were described. It is almost general practice in Europe to machine Kaplan runner blades on all sides. Propeller-type turbines have been installed with specific speeds up to 218. In high head-plants using impluse wheels it is common practice to use two nozzles per runner and frequently two or three such runners are used on the same horizontal shaft, placed close together and all on one side of the generator. Vertical-shaft units have been built with as high as four nozzles per runner. Pumped-storage plants have been installed extensively, particularly in Germany and Switzerland. Some of these plants have nearly 200,000 hp. installed turbine capacity and over 100,000 hp. of pumps.

Dr. K. Fischer and Dr. D. Thoma in a paper "Investigations of the Flow Conditions in a Centrifugal Pump" gave an account of research recently made in the laboratory of the Technical University of Munich, Germany, into flow conditions in the impeller of a centrifugal pump. On this pump the entire impeller and the guide vanes were clearly visible through a plate-glass wall that took the place of the outside pump case and formed the front shroud of the impeller. Observations of flow were made with a rotoscope, a device that makes rotating objects appear to be stationary.

Investigations of a rational solution offering formulas for the tail-water depth of the hydraulic jump were given in a paper "Hydraulic Jump in Sloping and Horizontal Flumes," by Robert W. Ellms. A recent study of the mathematical analysis of this phenomenon has revealed certain interesting relationships that are discussed in the paper. The conclusion drawn from this study is that Prof. W. C. Unwin's momentum formula is a special case of a more general formula that can be used to include jumps produced in both sloping and horizontal flumes.

THE ENGINEER'S BOOKSHELF

Power Generation and Transmission

ELECTRIC POWER EQUIPMENT. *By J. G. Tarboux, Professor of Electrical Engineering, University of Tennessee. Published by McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York City, 1932. Cloth; 6x9 in.; 382 illustrations; 20 tables; 493 pages. Price $5.00.*

Written primarily as a text or reference book for students in electrical engineering who have had a course covering electric circuits and machinery, this book embraces practically the whole field of electric power generation and transmission lines. The treatment gives a general knowledge of the details, operation and application of electrical power equipment. The scope of the book is broad, starting with a brief survey of power resources, a study of prime movers, the relation of steam to water power, a discussion of loads and load graphs, then taking up electric generating, transforming and converting equipment, power-plant circuit layouts, switching equipment, switchboards, calculation of short-circuit currents, transmission lines, protective equipment and closing with a chapter on the economics of electric service.

This is the second edition, and the book has been brought up to date by including new types of circuit breakers, oil switches and metal-clad switchgear, improvements in transformers, including tap-changing equipment, and a new type of thermal demand meter. The discussion on voltage regulators and other subjects has been broadened and the chapter on economics of power generation has been greatly enlarged. Although the subjects have been treated primarily for electrical-engineering students, the presentation in general is practical and can be understood by readers who have only a practical knowledge of electrical machinery.

Metallurgy

A TEXTBOOK OF METALLURGICAL PROBLEMS. *By Allison Butts, Associate Professor of Metallurgy, Lehigh University. Published by the McGraw-Hill Book Co., 330 W. 42nd St., New York City. 1932. Cloth; 6x9 in.; 425 pages; 53 tables. Price $4.*

This is a book of problems to supplement Prof. Joseph W. Richards' "Metallurgical Calculations," but is intended primarily for instruction of college students. It, however, in general continues the methods of the previous volume, extends further in certain directions, and contains new and revised data which have come to light since Prof. Richards' death. This volume applies thermodynamics to the study of chemical and metallurgical reactions. Power engineers may be interested in the chapters on "Quantities and Units," "Combustion," "Thermo Chemistry and Thermo Physics," "The Heat Balance," "Production of Blast and Draft," "Transmission of Heat," and "Thermodynamics of Chemical Reactions." The tables are unusually complete.

Design of Open Channels

HYDRAULICS OF OPEN CHANNELS. *By Boris A. Bakhmeteff. (Engineering Societies Monographs.) Published by McGraw-Hill Book Co., 330 W. 42nd St., New York City. Cloth, 6x9 in.; 329 pages. Price $4.*

To the engineer concerned with the design of open channels, Professor Bakhmeteff's latest volume offers a comprehensive treatment of the phenomenon of varied flow. He has compiled under one subject the contribution of outstanding physicists and engineers in a most logical and lucid manner, and presents original parameters and flow functions to aid in a clear understanding of the characteristics of water in motion. The style of presentation is simple and effective, laying emphasis on an understanding of the phenomena and the limitation of present knowledge in establishing a complete analysis of many characteristics of flow, thus keeping the student alert to the fact that formulas are of value only when used with a clear understanding of their application and limitation.

The author has made an exhaustive study of the available literature on the subject, and it is significant to note that a treatment of two essential conditions of local phenomena is absent; i.e., curvilinear and confluent flows in open channels. This is a strategic move on the author's part, and his frankness is most refreshing when he states in the preface, "Many problems are too complicated to be dealt with on a practical basis; in other instances, the actual state of the art is inadequate." Suitable examples are worked out illustrating the actual computation of specific problems. An abundance of clear-cut, effective plates illustrate the subject matter throughout the volume. An appendix is included with historical and bibliographical notes, original tables of the varied flow functions, and plates illustrating the characteristics of practical canal cross-sections.

BRIEF REVIEWS

FOREIGN DEVELOPMENTS. A report of the Prime Movers Committee, Engineering National Section, N.E.L.A. 26 pages, illustrated. Published as N.E.L.A. publication No. 226, and available from the Association at 420 Lexington Ave., New York City, for 50 cents to members, 75 cents to non-members.—A review of latest power plant design and practice abroad. Developments in newer boiler and turbine designs are illustrated and described. A bibliography is included.

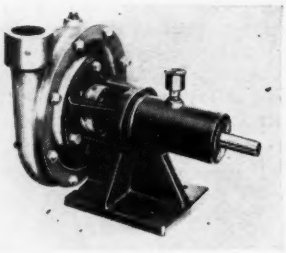
1932 DIRECTORY FOR THE CORRELATION OF THERMAL RESEARCH. Issued by the Research Laboratory of the American Society of Heating and Ventilating Engineers, 51 Madison Ave., New York City. (Laboratory at 4800 Forbes St., Pittsburgh, Pa.)—Listing laboratories, bureaus, societies, associations and other organizations engaged in, supporting or otherwise interested in research, codification, standardization or improvement of practice in the field of thermal engineering, with especial reference to heating and ventilating.

REPORT OF COMMITTEE A-5 ON CORROSION OF IRON AND STEEL. Published by the American Society for Testing Materials, 1315 Spruce St., Philadelphia, Pa. 56 pages, 6x9.—A preprint of the report presented at the 1932 annual meeting. Quite a bit of material is included on developments during the past year.

JAHRBUCH DER VERKEHRSDIREKTION (1931) (Yearbook of the Operating Department). Published by the Berliner Stadtische Elektrizitatswerke A.G. (Berlin Electrical Works) Berlin, NW 6, Schiffbauerdamm 22, Germany. Cloth; 6x9 in.; 138 pages. 90 illustrations and diagrams.—The yearbook, one of a series of reviews by the various departments of the Berlin City Electrical Works, discusses developments of the past year, and includes statistics, illustions of new instruments, displays and installations. Written in German.

PLANNING AND BUILDING THE CITY OF WASHINGTON. By the Washington Society of Engineers; edited by Frederick Haynes Newell. Illustrations, frontispiece, 82 halftones, 8 maps, 5 charts, 4 appendices. Cloth, 5¼x8 in. 252 pages. Price $2. Published by Ransdell Incorporated, 810-16 Rhode Island Ave., N.E., Washington, D. C.—A graphic account of the planning and construction of the Capital City.

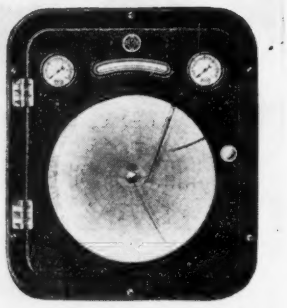
WHAT'S NEW IN PLANT EQUIPMENT



Ball-Bearing High-Efficiency Pumps

Chemicals and liquids can be handled, since pumps are available in any machinable ferrous or non-ferrous alloy. Removable inboard and outboard heads, split screw gland stuffing box, interchangeable parts, ball bearings on shaft and impeller. Extremely close clearances claimed. Furnished with or without motor drive.

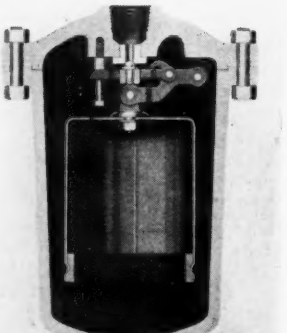
Hills-McCanna Co., 2349-59 Nelson St., Chicago, Ill.



Temperature Controller with Compensating Feature

This recording temperature controller has "thermo-pressure compensator" which permits controller to control temperature by throttling supply of cooling or heating medium and also compensates pressure and resultant rate of flow of medium in order to prevent temperature changes due to pressure changes. Compound balanced pilot valve controls diaphragm control valve, dual helical temperature coils check each other (one operates control, other inscribes record).

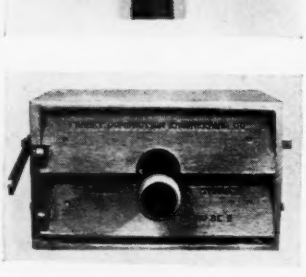
Mason Regulator Co., 1190 Adams St., Boston, Mass.



Inverted Bucket Trap

Type A trap has stainless steel seat and disk, claimed to have large capacity, small wear, and to be full-opening, non-air-binding and non-fouling. Inlet and outlet are in line for ease of installation. Hexagonal section at bottom. Bucket one-piece spun copper; levers phosphor-bronze. Accommodates pipe sizes from ½ to 2 in.

Swartwout Co., 18511 Euclid Ave., Cleveland, Ohio.



Low-Pressure Gas Burner

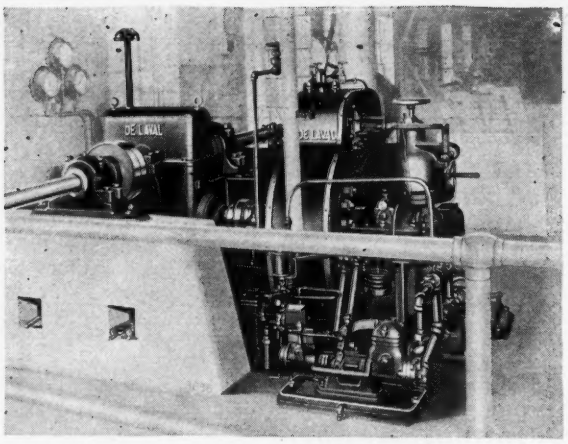
Type BL is made for gas pressures of 2 to 8 oz. Six sizes vary in capacity from 25 to 3,000 sq.ft. of boiler heating surface. Rectangular, it fits most present boiler openings. Head is heat-resisting alloy; louvre-type air dampers operable automatically.

Forney Combustion Engineering Co., 513 Central Bank Bldg., Dallas, Tex.

Shaped Welding Nipples

Shaped welding nipples are claimed to eliminate all templates when saddling one pipe upon another. Nipple is placed in position before opening is cut, opening being traced from nipple contact line. Both shaped and square nipple ends are beveled for welding. Both 90-deg. and 45-deg. types are of standard or heavy wrought steel pipe and wrought iron pipe; sizes are from 1¼-12 in. Specials can be provided with forged laps of flanges or in other angles, lengths and sizes.

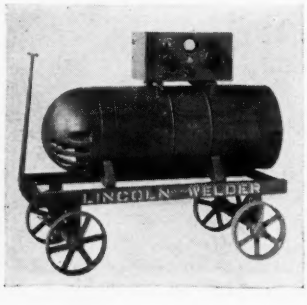
Midwest Piping & Supply Co., Inc., St. Louis, Mo.



Arc Welder

"Shield-Arc" welders, claimed to provide uniform welding current and thus give faster welding and greater deposit per kw.-hr., rated at 40 volts instead of former 25 to suit newer rods. Stabilizer or kick transformer eliminated in this design. Dual control provided for independent regulation of current and voltage. Reversible voltage control reverses direction in which current is generated, consequently eliminates shifting of cable connections to change polarity of welding current. Center-reading volt-ammeter mounted on control panel shows negative or positive polarity as well as volts and amperes. Control panel mounted vertically in convenient position. Welder entirely inclosed of arc-welded steel construction. Generator field laminated. Available in a.c. and d.c. motor-driven types of 300-, 400- and 600-amp. sizes. Removable running gear and drawbar.

Lincoln Electric Co., Coit Road and Kirby Ave., Cleveland, Ohio.



Variable-Speed Governor for Steam Turbine Drives

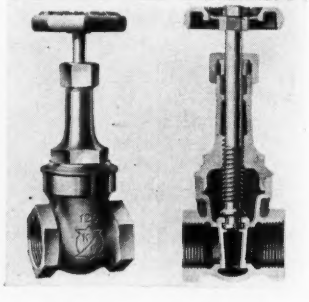
Mechanical variable-speed governor, positively driven through gears from turbine shaft and acts directly on speed control valve, shown applied in photo. Speed of gear shaft may be regulated by means of small handwheel at top of governor casing, an indicator below showing speed of driven machine. Adjustments up to 16 to 1 are possible. Can operate at turbine or by remote control. Actuates a balanced, double-seated, steam admission valve through a lever arrangement. Speed governor valve and emergency over-speed shut-off valve in housing formed by turbine case cover.

DeLaval Steam Turbine Co., Trenton, N. J.

Rising Stem Bronze Gate Valves

For 125-lb. steam and 175-lb. water pressures, these rising stem bronze gate valves have same solid wedge disk mechanism as standard Kennedy stationary stem bronze gate valves. Simple mechanism. Flexible connection between disk and stem to prevent binding and springing when valve is closed. Stem bronze composition with number of contact threads in bonnet. Bonnet hexagon made large to prevent distortion. Deep stuffing box with gland and square-section molded packing rings.

Kennedy Valve Mfg. Co., Elmira, N. Y.



Bar Stock Valves

For services where high strength and close control are required, ¾- and 1-in. globe valves, precision turned from carbon steel, have stainless steel renewable slip-on disks and screw-in seats. Stems are designed and treated for temperature service; other parts are Parkerized inside and out to improve appearance and protect against corrosion. Smaller size valves, both globe and angle patterns, have integral seats and disks. Working pressures are 4,000 lb. at 150 deg. F., 600 lb. at 500 deg. F. Other valves are: bronze globe, angle and cross types for 500 lb. at 150 deg. in sizes up to ½ in. Stainless steel globe and angle types in sizes up to 1 in. and pressures up to 4,000 lb. at 150 deg. F. and 600 lb. at 150 deg. F. Can be furnished with indicator handwheels, lock shield and key, male or female unions, male and female ends, or three valves on a single body, as specials.

Reading-Pratt & Cady Co., Inc., Bridgeport, Conn.

Hand-Operated A.C. Starting Switch

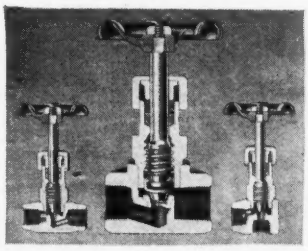
Bulletin 609 compact manually operated starting switches will control small a.c. motors and give overload protection, according to maker. Two overload relays are provided; tripping of either relay opens contactor and disconnects motor from line. Either relay can be reset without opening cabinet. Switch closed and opened by two operating buttons extending through cabinet cover. Two sizes, Size 1 (smaller) 3-pole; Size 2 has 3 and 4 poles. Size 1 will handle self-starting single-phase motors up to 1 hp., 110 volts and 2-hp., 220 volts, and polyphase motors up to 2 hp. at 220, 440 and 550 volts. Size 2 is rated at 5 hp., 220 volts and 7½ hp., 440 and 550 volts, for 2- and 3-phase motors.

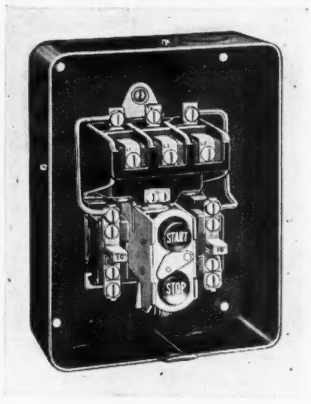
Allen-Bradley Co., 1311 South First St., Milwaukee, Wis.

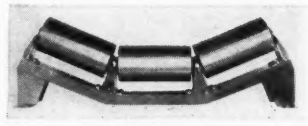
Anti-Friction Conveyor Carrier

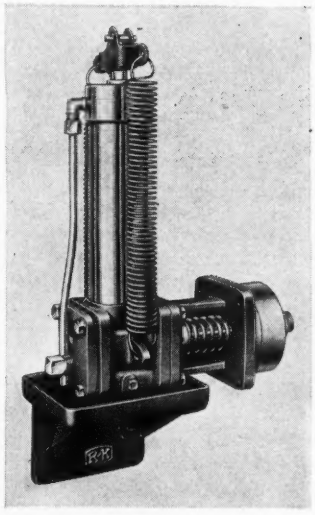
Interchangeable Shafer roller bearings of self-aligning type are used to take thrust and radial load in these carriers. Can be interchanged with any standard carriers. Roller is 5½-in. diameter seamless tubing, No. 9 gage; ends of pressed steel with pressed-in outer roller races. Inner tube 1¼-in. diameter with shoulders at both ends. Spindle, ¾-in. diameter, cold-rolled, drilled and tapped for grease fittings, slotted to fit end brackets, provided with two flats to lock grease-seal washers. Load rating of each roller bearing is 450 lb., carrying capacity of carrier 600 lb. with 4½ factor of safety. Rounded roller edges protect belt; rollers supported on pressed steel brackets bolted to channel base.

Barber-Greene Co., Aurora, Ill.









Hydraulic Damper Regulator

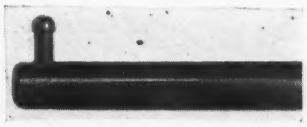
"Midget" stoker and damper controls for coal, fuel oil or gas-fired boilers are actuated by water pressure and will control damper adjustment, or both damper and fuel feed where automatic stokers are used, within a variation of ¼ lb.

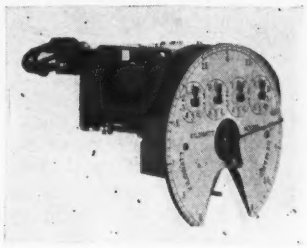
Ruggles-Klingeman Mfg. Co., Salem, Mass.

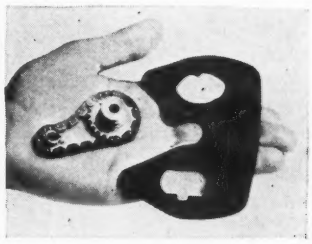
Non-Metallic Switch Hook

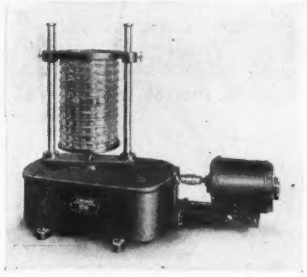
This switch hook is composed entirely of insulating materials, permitting closer mounting of adjacent switches.

General Electric Co., Schenectady, N. Y.









Steam Trap

Number 11 "Silvertop" steam trap, light and small, is claimed ideal for use in heating coils, unit heaters and other auxiliary equipment. Furnished chrome-plated and polished as extra. Working parts are stainless steel. One-bolt assembly. Valve and seat are Nitralloy, heat-treated. Can be used either as an elbow or straight-in-line. Non-air-binding and automatic. Regular, ½-in. pipe connections; ¾-in. connections if desired.

V. D. Anderson Co., Cleveland, Ohio.

Watthour Demand Register

Combining regular watt-hour meter register with scale and pointers of an indicating block-interval demand meter, this watt-hour demand register converts standard single- or polyphase OB watt-hour meters into indicating block-interval demand meters. It replaces register and cover. After change, meter will indicate maximum kilowatt demand and integrated kilowatt hours. May be used wherever indicating type of demand meter is satisfactory, particularly in smaller power installations. Known as Type DR attachment.

Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Small-Pitch Silent Chain Drives

Silent chain drives from ⅜-in. to 3-in. pitch are now available with refinements in design. Shown are ⅜- and 3-in. pitch sizes.

Morse Chain Co., Ithaca, N. Y.

Testing Sieve Shaker

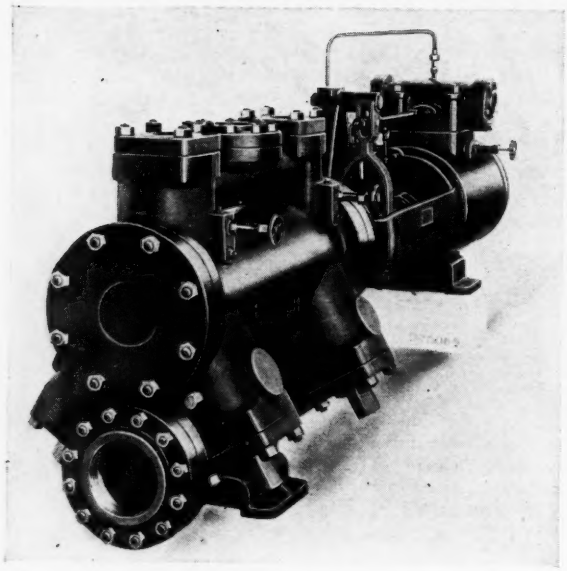
"End-Shak" testing sieve shakers are claimed to eliminate most of the variable factors in sieve testing, to use fundamentally sounder principles, to spread sample uniformly over sieve surface, to utilize entire sieve surface by combined rotating and reciprocating movements, to minimize wear and tear on parts and to eliminate jumping and bouncing of sample particles. Weight, 275 lb., including motor and auto time switch. Height, 29 in.; base, 33x13 in. ¼-hp. motor, 110 and 220 volt, 60-cycle a.c., 1,750 r.p.m. Belt drive or special motor equipment if desired. Designed for 8-in. diameter testing sieves, and adjustable to hold from 1-13 sieves.

Newark, Wire Cloth Co. Newark, N. J.

Hydraulic Refractory Concrete

"Hydrecon," for operating temperatures to 3,000 deg. F., comes in 125-lb. lined burlap bags containing everything needed but water. Handled, poured, tamped and rammed like concrete. Claimed to have low coefficient of heat transfer, resistance to spalling from sudden thermal changes, low coefficient of expansion, and to form monolithic refractory lining for boiler furnaces, checker chambers, stack and stove linings, kilns, furnaces and oil stills.

J. H. France Refractories Co. Snow Shoe, Pa.



Direct-Acting Close-Clearance Steam Pumps

"HiVol" steam pumps are claimed to show clearances of 12-17 per cent, attained by applying principles of gas compressor design. Suction and discharge valves are at extreme end of liquid cylinder, suction below and discharge above the piston on vertical center line of cylinder. This gives straight-line flow of liquid through cylinder, maximum suction valve area, and minimum volumetric clearance, according to maker. Hand bypass valve fitted. Liquid cylinder of Wompco metal, designed for 400-lb. working pressure. Cylinder liner, Ni-Resist, removable.

Worthington Pump & Machinery Corp., Harrison, N. J.

"Vest-Pocket" Size Spray Nozzle

These Rex die-cast aluminum spray nozzles are offered for removing débris from intake screens, sluicing ashes and for similar services. Non-clogging, but economical of water according to maker, because of flat spray sheet produced by impinging round stream on curved deflector plate with retaining sides.

Chain Belt Co., Milwaukee, Wis.

Single-Line Multi-Feed System for Greases

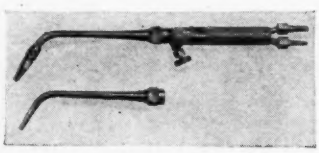
For mechanical application of light greases and heavy oils to parts requiring regular lubrication, this motor-driven single-line system is claimed to be positive, accurate, rugged, and simple. A grease pump loads the hopper. Heating unit warms grease in winter. Main unit placed conveniently; single feeder line taken to farthest point requiring lubrication. Branch lines then taken from main line to each bearing. Independent mechanical measuring units at each bearing permit only desired quantities to pass. Visible evidence that valve is operating. Pressure on line only during lubrication. Systems can be motor-driven, mechanically operated or operated by hand crank. Hoppers, valves and motors varied to suit service.

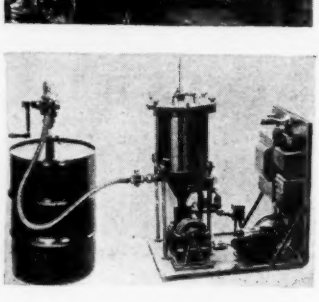
Hills-McCanna Co., 2349 Nelson St., Chicago, Ill.

Welding Torch

Oxweld Type W-22 welding blowpipe, developed originally for pipe line work, is similar to Type W-17 except that oxygen and acetylene valves are on front of handle for easier flame adjustment while in operation. Acetylene valve on left side of handle for ease in thumb adjustment. Long acetylene passageway between valve and injector claimed to minimize flashback possibility. Stainless steel ball-type acetylene valve. Type W-17 heads are used, and CW-17 cutting attachment, with this torch.

Linde Air Products Co., 30 East 42nd St., New York City.





Asbestos-Covered Steam Hose

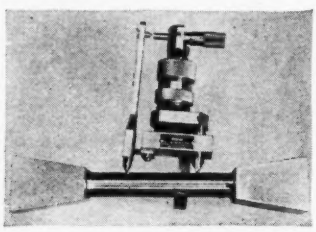
This Type 26 steam hose has a carcass of braided asbestos cords combined with wire. The sizes vary from ½ to 2½ in., all sizes 1 in. and up in three-braid construction (asbestos, wire, asbestos). Two braids (asbestos and wire) are used in ½- and ¾-in. sizes. 50 ft. is maximum length. Claimed to resist heat much better than usual cotton-fabric hoses with rubber covering.

Goodyear Tire & Rubber Co., Akron, Ohio.

Extensometer

Oxweld extensometers make possible determination of yield points of specimens being tested in Oxweld portable tensile testing machines. Highly sensitive, yet claimed to be simple, rugged, self-contained and self-compensating. Two points of unit clamped on specimen in such manner that elongation between points is multiplied in 5-1 ratio by lever bar making electrical contact with micrometer head. Moment of electrical contact indicated by electric light in head, thus permits simultaneous determination of ultimate strength and yield point. May also be used as strain gage to indicate elongation of specimen under specific load.

Linde Air Products Co., 30 East 42nd St., New York City.



Improved Concentration Hydrometer

For determining total dissolved solids in boiler waters, this concentration hydrometer consists of but one float and one tube, all scales being inclosed in the float. Claimed quick-acting because of mercury thermometer and space between tube and float, together with projecting knobs on float to lessen friction. Hexagonal lower fitting, preventing rolling, is removed to take instrument apart for cleaning.

Dearborn Chemical Co., 310 South Michigan Ave., Chicago.

Rust-Preventing Coating

"Rust-Tox," claimed capable of resisting heat up to 550 deg. F., acid fumes, smoke, salt air and oxygen, can be sprayed or brushed at any temperature above 35 deg. F. "Bakes on" under rivet heads in plate joints to leave water and airtight coating. Can be used as vehicle for aluminum flakes, red lead or graphite. Can be applied on slightly rusted surfaces.

The Skybryte Co., 1919 East 19th St., Cleveland, O.

Non-Slip Elevator Cable Compound

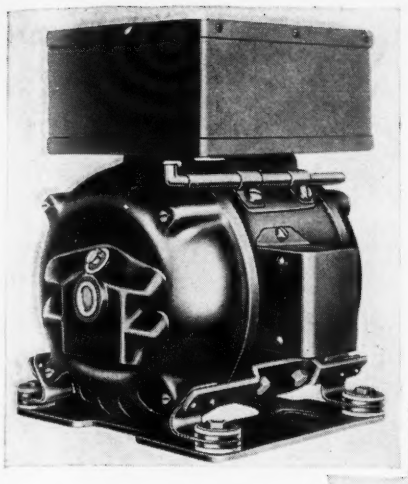
"H-C" non-slip elevator cable compound claimed to lessen cable slippage, which causes unequal tensions, false stops and signal system troubles.

Hazard Wire Rope Co., Wilkes-Barre, Pa.

Chain Pipe Wrench

"Fulrange" chain pipe wrenches are reversible and operable in either direction without removing pipe or adjusting chain. Maker claims positive grip at any angle and ability to operate efficiently in corners and about obstructions, since wrench grips from front instead of side. Ratchet action incorporated No. 1 size handles pipe from ⅜ to 1½ in., also tees, elbows, and street fittings.

American Industrial Corp., 250 Park Ave., New York City.



Capacitor Motors

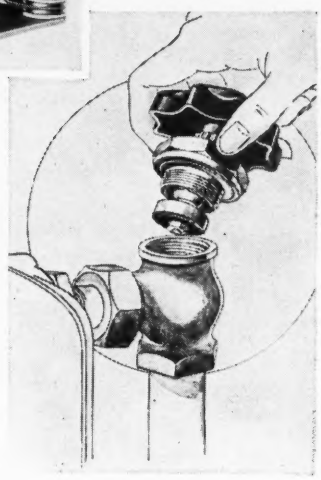
Sizes from ⅛ to 10 hp. for single- or multi-speed operation with normal- high- or low-torque characteristics are included in this line of capacitor motors. Small sizes have capacitor mounted on top of motor, although boxes can be supplied for wall mounting as in larger sizes. Intermediate sizes have separate capacitor boxes which may be furnished for either wall or floor mounting. Operating characteristics cover wide range of applications.

Century Electric Co., St. Louis, Mo.

Pneumatic Switch for Controllers

Compact and simple, this switch is claimed to make possible the use of air-operated controllers on equipment controlled by electricity, such as pumps, blowers and compressors, or to produce audible or visible signals on time cycle applications. Switch is standard single-pole mercury switch mounted in cast-iron housing with outlet tapped for either conduit or BX connector. With suitable auxiliary magnetic switches, it may be used in any circuit where current is not higher than 600 amp. at 220 volts. Switch operated by diaphragm motor mounted on housing, closed by air pressure from control instrument, opened by spring.

Foxboro Co., Foxboro, Mass.



Valve Bonnet Replacement Assembly

No special tools, machining, reaming or fitting are required in applying the Type R bonnet assembly to old valves. It is a replacement unit designed to modernize any size or standard make of packed or packless inlet valve. Assembly is packless, of quick-opening high-lift construction, and ease of operation and accuracy of control are claimed. It is inserted as indicated in the illustration.

Jas. P. Marsh Corp., 2073 Southport Ave., Chicago, Ill.

Water Gage Adapter and Gage Glass Light

"Incline-A-Gage" is used to change a regulation or vertical water gage into an inclined gage. It has special adapter fittings with self-contained washers ahead of the gaskets to prevent fittings from blowing off. Reinforcing rods prevent shifting of position in service. Bronze and steel form the unit. "Gage-Lite" has a two-piece cast aluminum case—light case and door. Door acts as reflector to concentrate light on gage glass. Face protected by ¼-in. plate glass ¾ in. wide. Takes 50- or 60-watt bulb.

Reliance Gage Column Co., 5902 Carnegie Ave., Cleveland, Ohio.

Automatic Proportioning Pump

For controlling injections of accurate percentages of chemicals or reagents in treating operations or for securing accurate samples of liquids, Tret-O-Unit pump is controlled by the flow of untreated fluid. Assembly consists of a hydraulically balanced control valve, shuttled back and forth to control strokes per minute taken by fluid motor above it. Fluid motor is direct connected to single stroking plunger pump which charges treating fluid. Access yoke contains reagent plunger adjusting and locking device. Wide range of sizes and materials, including diaphragm instead of plunger for abrasive or corrosive fluids.

Proportions, 7701 Avalon Ave., Chicago, Ill.

Oxygen and Acetylene Regulators

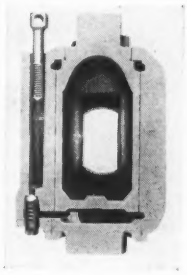
Oxweld Types R-48 (right) oxygen and R-49 (left) acetylene regulators are for light-duty use, particularly with Type W-15 welding blowpipe. R-48 has a new type of safety release. Hose connections on R-48 are for ¼-in. oxygen hose, on R-49 for ⅜-in. acetylene hose. Other sizes if required.

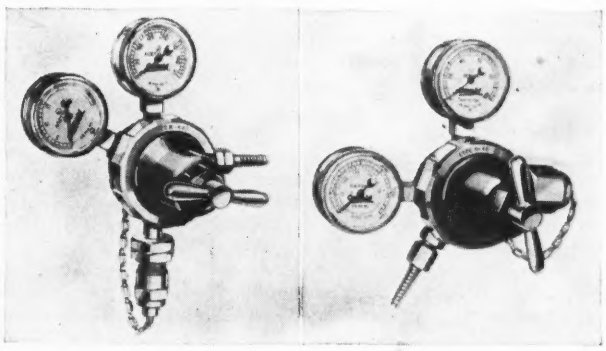
Linde Air Products Co., 30 East 42nd St., New York City.

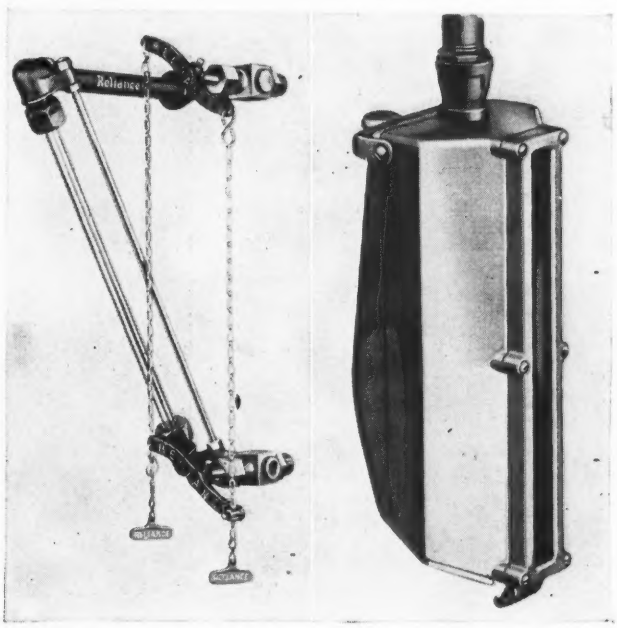
Plug-Type Lubricated Improved Valve

Only seven parts are included in this Milliken valve for pressure work. Originally had movable gland in head, head being held to body by gland bolts. Now made with solid head which avoids blands, bolts, bonnets and stuffing boxes. Valve opens and closes with a quarter turn against a positive stop. No seats. Face-to-face dimensions of flanged valves same as standard gate valves. Special steel for heavier sizes.

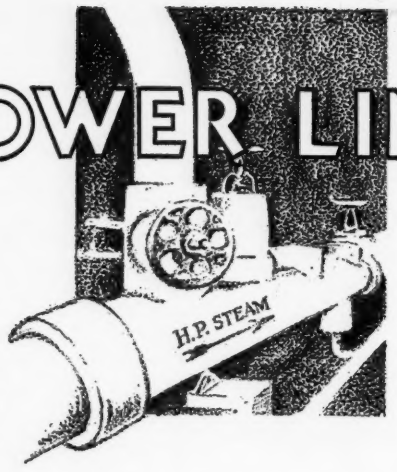
American Car & Foundry Co., 30 Church St., New York City.







POWER LINES



Oil Fire at Bremo

ON JUNE 28, fire caused by a broken lubricating oil line did considerable damage to one end of the turbine room of the Bremo Bluff plant of the Virginia Public Service Co., which went into operation last year. A lubricating oil line on one of the 15,000-kw., 3,600-r.p.m. turbines ruptured, and the oil issuing from the break, on coming in contact with a 750-deg. steam line, immediately ignited. The fire progressed to a lubricating oil reservoir directly under the turbine room floor.

Either the oil overflowed the reservoir or the tank was ruptured from the heat, allowing oil to flow to the turbine room basement, where it caused additional damage to some auxiliary motors. The fire burned furiously for about an hour.

The tiled interior of one end of the turbine room was ruined, the turbine-room crane was damaged. Control cables and cable feeding auxiliaries were injured. It is thought that the intense heat may have caused some damage to the turbine cylinder, but this and the extent of other damages has not yet been determined. If the turbine was seriously injured the damages may exceed $500,000.

The turbine involved in the fire was shut down by operating the steam valve in the boiler room. The No. 1 unit was not injured and is now in operation delivering current to the system, which extends from Alexandria, Va., to Hinton, W. Va., and also throughout much of central and southern Virginia.

Stevens Institute Plans Second Summer Camp

Stevens Institute of Technology is holding its second college camp for preparatory school boys from Aug. 13-27. The camp is planned to assist boys in deciding whether or not they plan to go to college, the type of college they prefer to attend, and the kind of career they should plan. Advantages and disadvantages of engineering careers are explained and an effort made to present the subject clearly and completely to permit the boy to make an individual unbiased decision.

Silver Bay Institute Now Holding Sessions

How has American industry fared in the world depression, and what lessons have been learned that may be advantageously applied in meeting the new and manifold problems with which every industrial concern in the country, large and small, is faced today? These and many other matters of concern to the American industrialist are being discussed at the 1932 session of the Silver Bay Industrial Institute now meeting at Silver Bay, N. Y. The Institute, of which Arthur H. Young, Industrial Relations Counselor, is chairman, is holding sessions from July 8 to 22. Executives of America's largest industrial units will participate in a series of group discussions, while at the same time representatives of many of the nation's smaller industries scattered from coast to coast will consider the problems of the thousands of industrial units which ordinarily employ less than five hundred workmen but which in the aggregate account for more than 60 per cent of all industrial labor in the United States.

Hydraulic Laboratory Building Occupied

The National Hydraulic Laboratory Building at the Bureau of Standards in Washington has been completed and accepted and the staff is now occupying it. The personnel at the present time consists of H. N. Eaton and the four other men, all of whom have been on the Bureau of Standards Staff since the Laboratory was started.

Equipment is being installed, and it is understood that in about three months some experiments dealing with losses in channel bends will be started.

Operations at the Laboratory will be decidedly handicapped because of the present cut in the appropriation as a result of the Government economy drive.

COMING MEETINGS

10th National Power Show—Grand Central Palace, New York City, Dec. 5-10, during annual meeting, A.S.M.E. Conducted by International Exposition Co., Grand Central Palace, New York City. Charles F. Roth and Fred W. Payne, managers.

International Electrical Congress—Paris, France, July 4-12.

Universal Craftsmen Council of Engineers. Annual convention at Cedar Point, Ohio, Aug. 8-13. Secretary, T. H. Jones, 33 Linden Ave., Cherrydale, Va.

Safety Congress and Exhibition—21st Annual, Washington, D. C., Oct. 3-7. Headquarters of the National Safety Council, Sponsor, 20 N. Wacker Drive, Chicago, Ill.

American Institute of Electrical Engineers—Pacific Coast Convention, Vancouver, B. C., Aug. 29-Sept. 2. Middle Eastern District meeting, Oct. 10-13, Baltimore, Md. National Headquarters, 33 West 39th St., New York City.

Second Conference of Smaller Industries—Silver Bay, N. Y., July 11-16. A part of the Silver Bay Industrial Institute, July 8-22. C. R. Towson, secretary, 347 Madison Ave., New York City.

$10,000 000 Pipe Contract Subject of Suit

Counsel for the A. O. Smith Corp. of Milwaukee notified the Interior Department at a hearing July 5 that if the $10,000,000 contract (largest pipe contract in history) for the Hoover Dam penstock and outlet pipes is awarded to Babcock & Wilcox Co., of New York, they will bring suit for injunction alleging patent infringements that would indefinitely delay construction of the dam.

$10,000,000 Bond Sale Asked for Colorado Aqueduct

The California Supreme Court has declared legal a $220,000,000 bond issue for the Metropolitan Water District. The District is now negotiating with the Reconstruction Finance Corporation for the sale of $10,000,000 of these bonds for the immediate commencement of work on the Colorado River aqueduct, a self-supporting and self-amortizing public project.

Sabath Resolution Means Power Plant Study

On Tuesday, June 21, the House of Representatives passed the Sabath Resolution No. 226. This provides a $10,000 fund and calls for an investigation by the House Committee on Post Offices into mail contracts, prices paid for post office building sites, construction contracts for post office buildings, to what extent collusive agreements, if any, have affected government work from any standpoint.

The Resolution also specifically provides for an investigation into the prices paid and contracts entered into for power, light and heat and in addition thereto estimated cost for generating power, light and heat in buildings now under construction and contemplated where plans have been drawn and where the cost of building is above $500,000.

It further proposes an investigation into the first costs and the operating costs for generating power, light and heat and for all government buildings.

Wire and Cable Standards Announced by A.S.A.

Three standards for wires and cables have been approved by the American Standards Association as follows: American Standards Definitions and General Standards for Wires and Cables, American Tentative Standard Specifications for Weatherproof (Weather-Resisting) Wires and Cables, American Tentative Standard Specifications for Heat-Resisting Wires and Cables.

The first of these, the definitions and general standards for wires and cables, include definitions and standards of general character which are applicable to wires and cables for power purposes and comprise a rearrangement of the A.I.E.E. standard No. 30 of October, 1928, which has been brought up to date with certain additions and the deletion of some of the tabular matter. The standard contains definitions for the various types of wires and cables, conductivity standards, designation standards, high voltage test standards, insulation resistance standards, capacitance or electrostatic capacity standards, and maximum temperature limits.

The Specifications for Weatherproof Weather-Resisting Wires and Cables cover weather-proof wiring and cables and the materials used for coverings and saturating compounds as applied to metallic conductors. The specifications are divided into the following headings: covering; saturating compound, which includes the tests therefor; stranded cables, which includes sizes of conductors and the stranding therefor; standard weights; a table of weights and weatherproof wires and cables; samples for tests; tests on copper conductors; and explanatory notes.

The Specifications for Heat-Resisting Wires and Cables (C8k2-1932) cover the usual type of heat-resisting covering commonly known as "slow-burning" as applied to metallic conductors for use in hot dry locations where the other types of insulation would not long endure or where the presence of large masses of inflammable materials would be objectionable.

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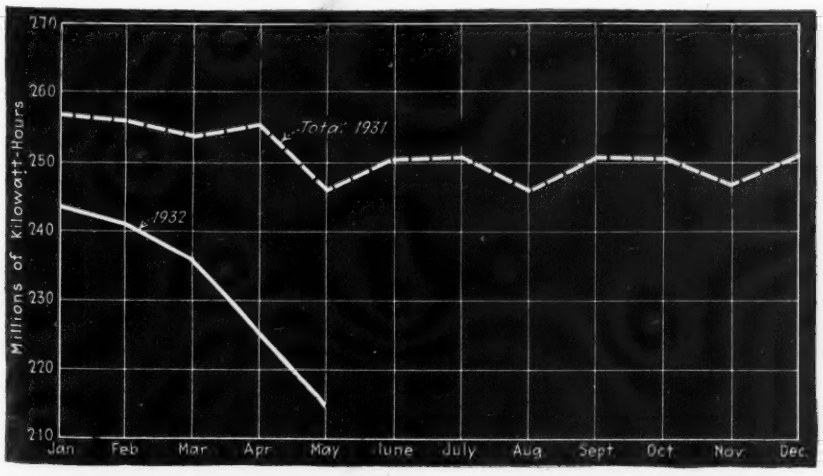
Public Utility Power Production Drops 7 per Cent in First Five Months

ELECTRIC POWER production of public utility power plants in the United States during the first five months of this year totaled 35,258,000,000 kw.-hr., as compared with 38,314,000,000 kw.-hr. produced in the corresponding period of 1931, according to figures just released by the Geological Survey of the Department of the Interior. This amounts to a decrease of 7 per cent from last year's production and a drop of 5 per cent under the production level of the same period in 1930.

As shown by the chart, average daily production of electricity by public-utility plants in May, 1932, was 213,800,000 kw.-hr., about 5 per cent less than the daily production for April. In 1930 the average daily production for May was about 1 per cent less than in January of the same year. The normal decrease in daily output from April to May is about 1.5 per cent, it is stated by the Geological Survey.

Average daily production of electricity by the use of water power in May of this year was about 1 per cent less than in April. During the first quarter of 1932 hydro-electric power amounted to 42 per cent of the total output, as compared with 31 per cent for 1931.

Power production figures of the Geological Survey are based on the operation of all power plants producing 10,000 kw.-hr. or more per month, engaged in generating electricity for public use, including central stations, both commercial and municipal, electric railway plants, plants operated by steam railroads generating electricity for traction, Bureau of Reclamation plants, public works plants and that part of the output of manufacturing plants which is sold for public use.



Average daily production of public utility power plants

Solid Fuel Men Meet in Chicago

Ways and means of furthering consumer satisfaction in the utilization of solid fuels occupied the attention of approximately one hundred representatives of the various branches of solid fuel and related equipment industries at the annual meeting of the Committee of Ten, Coal & Heating Industries, held June 20 at Chicago.

The work of the Committee was commended and, by various speakers, was eulogized as one of the most constructive efforts yet sponsored by the solid fuel industries. Pleas were presented by representatives of some of the related groups for expansion of the activities and for support to make an enlarged program possible.

Pointing out that the many ramifications of the work of the Committee and the intangible character of the program precluded a detailed analysis of accomplishments, Chairman H. A. Glover reviewed briefly in his annual report the aims of the Committee and the progress of the movement. His report was supplemented by brief discussions by other Committee members, after which the meeting was thrown open.

Officers unanimously elected for the ensuing year are: H. A. Glover, chairman; Lyle H. Dayhoff, vice-chairman; Carlyle M. Terry, secretary; Harry H. Kurtz, treasurer; Marc G. Bluth, assistant secretary-treasurer; Oliver J. Grimes, managing director.

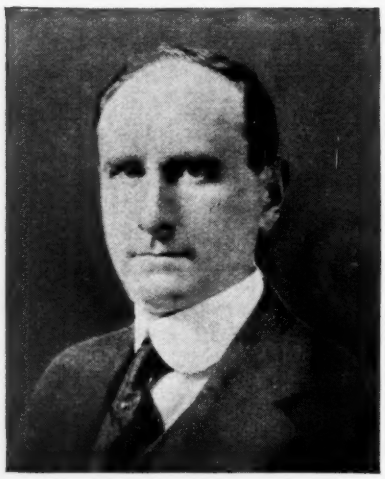
Pressure Gages Compared On Diesel Standards

The National Research Council of Canada, with the cooperation of McGill University, has been carrying on research work on piezo-electric pressure gages. In the investigation undertaken during the last year, the volume pressure curves of a diesel engine, known as the Petter hot-surface injection engine, were compared with the diagrams given by a mechanical indicator. The crystal sections, six circular quartz disks about 1 in. in diameter and each $\frac{3}{16}$ in. thick, were piled on top of one another in the form of a condenser and placed in a holder on which the pressure from the explosion reacted. The negative charges produced by the pressure were collected, and the potential differences amplified by radio tubes, the positive surfaces of the crystals being connected to ground. The pressure changes, appearing as variations in the output current were rendered visible with the help of an oscillograph having a known time scale. Knowing the position of the piston or the fly-wheel, the pressure-time curve obtained during one stroke was transformed into a volume-pressure diagram.

For calibration, the crystal indicator was removed from the engine and screwed into a special form of hydrostatic pressure apparatus. The curves obtained with the aid of the pressure-quartz proved to be of the same shape as those obtained several years ago with the Cambridge mechanical indicator. The maximum pressure observed during one cycle was about 310 lb. per sq.in.

Potter Nominated for A.S.M.E. Presidency

THE Nominating Committee, in session at the Bigwin meeting of the A.S.M.E., has named the following society members as candidates for election, to take office in the year 1933:



president, Dean A. A. Potter, Schools of Engineering, Purdue University; vice-presidents, Harold V. Coes, consulting management engineer, Ford Bacon & Davis, Inc.; J. D. Cunningham, president, Republic Flow Meters Co.; C. F. Hirshfeld, chief research engineer, Detroit Edison Co.; managers, Dean Robert L. Sackett, School of Engineering, Pennsylvania State College; A. D. Bailey, supt. Generating Stations, Commonwealth Edison Co.; John A. Hunter, professor of mechanical engineering, University of Colorado.

G. E. Establishes Air-Conditioning Unit

The newly created Air Conditioning Department of General Electric Co. will start commercial operations during the latter part of this month in 25 cities in the northeast, it has been announced by J. J. Donovan, manager. District sales representatives are now selecting local business firms to market the new line of air-conditioning and oil-heating equipment.

Cities in which commercial operations are to be started include Boston, Worcester, Springfield, New Bedford, Fall River, Providence, Hartford, New Haven, Bridgeport, Albany, Troy, Schenectady, Utica, Syracuse, Rochester, Jersey City, Newark, Trenton, Camden, Philadelphia, Baltimore, Washington, and New York.

Dr. Slepian Wins John Scott Medal

DR. JOSEPH SLEPIAN, consulting research engineer of the Westinghouse Electric & Mfg. Co., received the John Scott medal, certificate and premium of $1,000. The citation is awarded "for discoveries in the field of the deionization of gases and fundamental and outstanding inventions involving these discoveries."

Dr. Slepian's citation refers to conspicuous work in circuit-interrupting devices and the use of his unique principle of deionization in the destruction of powerful and violent electric arcs. His contribution was in making higher voltages possible on transmission lines and making this increased service both dependable and safe for central stations, industrial plants and private homes.

Chapman to Head Testing Materials Society

CLOYD M. CHAPMAN, consulting engineer of New York City, has been elected president of the American Society for Testing Materials for the year beginning June 24, 1932. He has designed and constructed several important electrical plants and other major developments and was at one time assistant to Edison in his private laboratory. WILLIAM H. BASSETT, metallurgical manager of the American Brass Company, has been elected vice-president of this Society. He has been with American Brass since 1913 and in his present office since 1930. He is a past president of the American Institute of Mining and Metallurgical Engineers.

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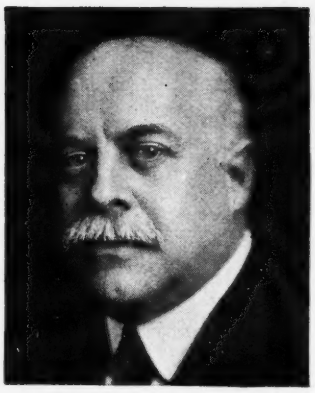
PERSONALS

JONATHAN CAMPNELL MELOON, 81, general mechanical superintendent of General Fire Extinguisher Co., Providence, R. I., died June 20.

E. F. SELLS has been appointed manager of the Washington, D.C., office of Westinghouse Electric & Mfg. Co., to fill the vacancy caused by the recent death of B. H. Hamilton. Mr. Sells has been associated with Westinghouse since 1911, serving a period of years in the Denver and El Paso offices.

ROBERT BAIRD WILLIAMSON, 59, electrical engineer and for 27 years a member of the engineering staff of Allis-Chalmers Mfg. Co., died at his home in Milwaukee, June 26. Since 1910 Mr. Williamson has had charge of the design of all alternating-current rotating machinery built by Allis-Chalmers. Mr. Williamson was a fellow of the American Institute of Electrical Engineers, serving a term on the board of managers of the Institute, also on a number of important committees.

Robert Williamson



Dr. George K. Burgess Dies Suddenly at Capital

DR. GEORGE K. BURGESS, 58, director of the Bureau of Standards and a prominent physicist, died July 2 in an ambulance while on his way to a hospital after having been taken ill in his office. Once before, on Oct. 28, Dr. Burgess was so stricken while at work. On that occasion he suffered from cerebral hemorrhage.

Dr. Burgess had been director of the bureau since 1923, and previously he had served in the same organization for twenty years. He was well known among scientists for his researches in heat measurements and metallurgy and had been appointed by his associates to numerous executive positions in the world of science. The new National Hydraulics Laboratory was completed under his supervision.

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BUSINESS NOTES

Walworth Co. and Nordstrom Valve Co. have entered into a cross-licensing agreement which permits each to manufacture lubricated plug valves under all of the patents of both.

The Babcock & Wilcox Co. has been granted the exclusive rights in the United States and Canada for the manufacture and sale of the automatic pressure circulating and indirect heating system of sulphite cooking developed by the Kimberly-Clark Corp. This process, which is patented, is being successfully used in six digesters in the Kimberly Mill, Kimberly, Wis.

Standard Piping & Fitting Co., 49th and Grays Ave., Philadelphia, Pa., has appointed C. W. Bergen, 30 Church St., New York City, as representative in New York and New England.

S. & S. Engineering Co., 2417 North Ashland Blvd., Chicago, Ill., has been appointed exclusive distributor for gas burners made by Denver Fire Clay Co.

Stephens-Adamson Mfg. Co., Aurora, Ill., has established a branch office at Rochester in the Cutler Building. F. H. Wisewell has been appointed district manager.

Allen-Bradley Co., Milwaukee, Wis., has opened an export office at 15 Laight St., New York City, with Arthur Rocke as export manager.

STRAWS

It's an ill wind that blows nobody good. Today, as always, there are innumerable activities of interest to the power field. Plans for better and cheaper power services are taking shape —new plants are going up—old plants are being modernized—things are being done. These "straws" reveal many patches of fair wind on the sea of American business

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From all indications, the trend of the weekly output of power plants is now upward and "the month of April showed the first gain in the number of electric meters in service since May, 1931."—*Detroit Edison Synchroscope.*

State Dept. of Inst., Sacramento, has acquired a site and plan construction of first unit of State Mental Hospital in Ventura County. Expenditure $375,000.

Columbia University, New York City, has bought two boilers for a total capacity of 135,000 lb. of steam per hour. The boilers are equipped with water walls and air heaters and are traveling-grate stoker fired. Combined heating surface, 19,330 sq.ft.

Julius Forstmann Co. has just bought three 60,000-lb. steam generating units for its Forstmann Wollen Co. plant at Passaic, N. J., and two 80,000-lb. steam generating units for its Garfield, N. J., plant. These units each consist of boilers, superheaters, air heaters, water-cooled furnaces with pulverized fuel firing and steel-clad insulated settings.

A manufacturer reports stoker orders from six companies and sales of three coal pulverizing units. In addition, this same company has received an order for 25 stokers to be built into combination stoker and boiler units.

Allis-Chalmers has just received an order from Los Angeles Bureau of Power & Light for three 10,000-kva. single-phase transformers; total price $62,000.

Imperial Laundry Co., Newark, N. J., has purchased a flue-gas scrubber.

Pasadena, Calif., plans the purchase of approximately 1,500,000 lb. of pipe, gates and valves, at a cost of about $200,000, for use in the construction of flood release outlets on the Pine Canyon Dam, now under construction. City officials have approved plans and specifications for the equipment, which will be manufactured, preliminary to calling for bids.

Application has been made to the Virginia state corporation commission by the Appalachian Electric Power Co. for a license for the hydro-electric development of the New River in Pulaski County, expected to cost about $12,-000,000 when completed. If built, the project will employ about 1,500 workers and will develop 190,000,000 kw.-hr. per year.

Philadelphia Quartz Co. has purchased a Freyn-design waste-heat boiler from Freyn Engineering Co., to be used for reclaiming waste heat released in manufacture of sodium silicate. This is the third installation of this type made by the company, the two previous being at the Baltimore, Md., and Berkeley, Calif., works.

The steamship "Washington," the second largest passenger vessel being built for the United States Lines, has just received her steering engine, which was manufactured by one of the most prominent builders of fuel charging equipment for boilers. That's diversification for you!

Long Island College Hospital, Brooklyn, N. Y., is installing a 3-cyl. vertical 14x12, 400-r.p.m., 300-kw. uniflow engine.

Completion of hydro-electric projects now in course of construction in the province of Quebec involves a capital outlay in excess of $75,000,000. This figure covers only those developments now actually under construction. Projects contemplated call for an additional $250,000,000.

The City of Vernon, Calif., has purchased metal-clad switch-gears for its diesel electric power plant for $150,000.

The Westinghouse Electric Elevator Co. has received a contract for the complete elevator system in the Agriculture Extension Building at Washington, D.C. The contract amounts to $263,750.

The San Diego Consolidated Gas & Electric Company awarded contract last week for the construction of a 12-mile pipe line connecting main systems in San Diego with Southern County Gas Co. The work involves an expenditure of $350,000.

A $700,000 public market building authorized by City Council, New Orleans, La., is to be constructed. Power substation equipment, motors, electrically operated ice-making and refrigerating machinery to cost about $75,000 will be installed.

Building and engineering contracts reported for May in the 16 southern states amount to more than $35,000,000, the largest monthly total so far this year.

Keppel & Rouf, wholesale candy manufacturers, Lancaster, Pa., are remodeling their plant. Refrigeration is being installed so that candy can be made in summer.

To take advantage of favorable power factor electricity rates, six Southern California manufacturing plants are replacing induction with synchronous motors.

About $100,000 will be expended by Idabel, Okla., for proposed city-owned electric light and power plant.

Philadelphia Electric Co. has just placed contract for 165,000-kva. steam-turbo-electric generating equipment. This will be installed in the Richmond Station on the Delaware River. Total cost of unit is $1,750,000. Cost of complete expansion program is $8,500,000. Work will require about two years.

Consolidated Gas, Electric Light & Power Co., Baltimore, Md., has installed a dust collecting fan in place of its induced-draft fan for its 12,500-sq.ft. boiler at the Terminal Power Station. The fan will produce 4-in. draft when developing 5,000 hp. and at the same time collect by ash and cinders otherwise eliminated through the stack.

Alco Products, Inc., division of American Locomotive Co., New York City, has received an order for distillation equipment of 6,000 bbl. capacity for the Pure Oil Co. at Smith's Bluffs, Tex.

Machine tool industry, considered by some a barometer of business, shows improvement in orders for first time in several years.

Permits issued for new construction in April gained 26.7 per cent over March, a more than seasonal upturn.

Los Angeles Bureau of Power & Light authorized on June 8 a call for bids on a steam plant to be built immediately. It will ultimately consist of three 65,-000-kw. turbines and four boilers. For the present, it is expected that one 65,-000-kw. turbine and two boilers will be purchased. Each boiler will be capable of supplying full steam requirements of the unit. About $4,000,000 in cash is on hand to the credit of the Bureau to finance early operations.

Department of Public Affairs, Newark, N. J., has called for bids on complete wire and electrical equipment for new city railway lines, in course of construction.

Machine drives, heavy-duty motors, transformers, etc., will be installed on oil refining plant of Shell Oil Co., Vancouver, B.C., on 80-acre tract near city. Cost about $1,000,000.

Metropolitan Water District, Los Angeles, Calif., plans project from Boulder Canyon, Nev., to Los Angeles to include transmission lines, transformers and sub-station equipment, to cost about $5,000,000.

New Brunswick Electric Power Commission, St. John, N.B., plans new transmission lines, rebuilding and improvements to cost over $400,000.

Puget Sound Power Co., Frank McLaughlin, president, has announced dividends totalling $533,477, at the regular rate.

Utah Oil Refining Co., Salt Lake City, is planning additions and alterations to its refinery, including installation of new-type gasoline absorption plant. Cost $400,000.

Columbia University, New York, is proposing a $7,000,000 30-story college building on its campus.

New Bulletins

WIRING POLICIES — National Electric Light Association, 420 Lexington Ave., New York, N. Y., has issued "A Statement of Wiring Policies," offering the policy of the Wiring Sales Committee of the N.E.L.A.

MECHANICAL OIL BURNERS—Schutte & Koerting Co., Philadelphia, has issued Bulletin 16A on mechanical fuel oil burning systems.

INDUCTION MOTORS—Reliance Electric & Engineering Co., Ivanhoe Road, Cleveland, Ohio, has issued Bulletin 111, on squirrel-cage induction motors, describing these motors and their construction.

REFRACTORY BRICK—American Refractories Institute, Pittsburgh, Pa., has issued Bulletin No. 35, "Development of a Method for Determining the Friability of Refractory Brick," dealing with the development of a method for determining the resistance to breakage of refractories during handling.

BOILER TUBE CLEANERS—Wm. B. Pierce Company, 45 N. Division St., Buffalo, N. Y., has issued a catalog on Dean universal tube cleaners, which now conforms in size with preferred specifications of the N.A.P.A.

CIRCUIT BREAKERS—The Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa., has issued a 76-page catalog, No. 2246, describing operation, construction and application of the Nofuze "Deion" circuit breaker, including prices for the various ratings. Suggested specifications are given.

COAL IN 1930—The Bureau of Mines of the Department of Commerce has issued a report under this title. It is Part II of the series, "Mineral Resources of the United States in 1930," and is available from the Superintendent of Documents, Washington, D. C., for 15 cents.

GAS CONTROL—Defender Automatic Regulator Co., St. Louis, Mo., has issued Bulletin DDD showing its new line of electric controls, damper regulators, and furnace draft regulators.

NATIONAL RESEARCH COUNCIL—The report of the National Research Council for the year July 1, 1930, to June 30, 1931, has been issued by the Government Printing Office and is available from the Superintendent of Documents, Washington, D. C.

NICKEL STEEL TOPICS—The International Nickel Co., Inc., 67 Wall St., New York, N. Y., has issued the initial number of "Nickel Steel Topics," a bi-monthly paper devoted to interests of users and fabricators in the nickel-alloy field. It is a 12-page illustrated miniature newspaper containing technical, semi-technical and news articles dealing with production, treatment and uses of these steels.

STEEL AND STEEL CASTINGS—The American Society for Testing Materials, 13-15 Spruce St., Philadelphia, Pa., has issued the following reports: "Symposium on Steam Castings," Report of Committee A-10 on Iron, Chromium, Nickel and Related Alloys, "Report of Research Committee on Fatigue of Metals," "Thermal Effects in Elastic and Plastic Deformation," by M. F. Sayre, "Report of Committee A-1 on Steel," "Report of Committee B-7 on Light Metals and Alloys, Cast and Rough."

THERMODYNAMICS—"A Proposition for the Correction and Renewal of Thermodynamics," by Toivo W. Salonen has been issued by the Akateeminen Kirjakauppa, Helsingfors, Finland, which discusses the theory of Clausius and claims to show the destructibility of energy. It is available for 80 cents from that source.

VALVES & FITTINGS—Crane Company, 836 South Michigan Ave., Chicago, has issued Circular No. 218A on Sealed Pipe Line, Refinery, Natural Gas and Natural Gasoline Plant Valves & Fittings. Included are fittings for welding, information on threading pipes and fittings and similar information.

BURNING OF LIQUID AND GASEOUS FUELS —A report of the Prime Movers Committee, Engineering National Section, N.E.L.A. Listed as N.E.L.A. Publication No. 219, and available for 30 cents to members, and 45 cents to non-members. It includes data on liquid and gaseous fuel market conditions, automatic combustion control, air heaters, use of oil and gas as auxiliary fuel, corrections in gas meters and gas calorimeters, rates of furnace heat liberation, and similar subjects.

New Plant Construction

Compiled by the McGraw-Hill Business News Department, Which Is Prepared to Furnish a More Complete Daily Service to Those Who Wish It

D. C., Wash. — Howard University awarded contract for 2 miles concrete tunnel, including plumbing, heating, power and distribution system to Goode Constr. Co., Charlotte, N. C. Estimated cost $236,728.

Idaho, Blackfoot—G. E. McKelvey, Comr. of Public Works, awarded contract for heating plant at state asylum, including furnishing and setting 390 hp. boiler and remodeling present heating plant, to C. C. Moore & Co., Sheldon Bldg., San Francisco, Calif., $19,985.

Ind., Ligonier — Common Council will receive bids until July 14 for the re-habilitation of the water works pumping system. Estimated cost $15,000. J. C. Kimmel is city clerk.

La., Monroe—City having plans prepared for a sewage pumping station to replace the one recently caved in at high water. W. I. Neely, Monroe, is engineer.

Mass., Boston—Quincy Market Cold Storage & Warehouse Co., 81 Wharf St., awarded contract for superstructure for 1 story, 35 x 70 ft. boiler house extension to Aberthaw Constr. Co., 80 Federal St. Foundations completed. Equipment not purchased.

Mich., Detroit—Dalton J. V. Snyder, 3125 Union Guardian Bldg., Architect, will receive bids about July 10 for the construction of a cannery, dairy barns, central boiler plant, machinery building, service station and out buildings in vicinity of Detroit. Estimated cost $75,000. Owner withheld.

Mich., Menominee — City has engaged Francis Engineering Co., Saginaw, engineers, to make preliminary surveys and plans for the construction of a municipal power and lighting plant, steam driven generating equipment.

Minn., Hutchinson—City plans the construction of a municipal electric light and power plant. Estimated cost $150,000.

Minn., St. Paul—City, C. R. May, Comr. Public Works, City Hall, is having plans prepared for the construction of a power plant and pumping station at McCarron St. Estimated cost $75,000. Complete equipment will be required.

Mo., Kansas City—Current River Power Co., Kansas City, received preliminary permit giving holder preferential right to develop 3 power sites, in. gravity type concrete dams, at Hargun Eddy, Mill Creek and Blair Creek, for hydro electric power projects.

N. Y., New York—New York Steam Corp., 280 Madison Ave., awarded contract for altering steam generating plant, including interconnecting 7 steel stacks by horizontal ducts with necessary supports, at 222 Pearl St., to Post & McCord, 101 Park Ave.

N. Y., New York—Bd. Transportation, J. H. Delaney, chairman, 250 Hudson St., taking bids July 15, constructing station sub-station, Essex St., between Stanton and Houston Sts.

N. Y., New York—A. H. Harper, 125 East 38th St., plans the construction of an apartment, stores and storage, including new central heating plant, boiler room, oil tanks and fuel oil burning equipment. E. H. Fougner, 207 Market St., Newark, N. J., is architect.

N. Y., Ozone Park — Sazrana Realty Corp., 9302 Jamaica Ave., Woodhaven, plans the construction of a 1 story, 27 x 85 ft. public market including refrigeration plant at Liberty Ave. and East 130th St. M. Pearlstein, Queens Village, is architect.

N. Y., Perinton—Village of Fairport have been given permission to build an electric plant and distribution system here.

N. Y., Reading—New York State Electric & Gas Co., Ithaca, plans construction of electric plant and distribution system here.

N. Y., Silver Springs—New York Central Electric Corp., 89 East St., Rochester, has made application to construct an electric plant and distribution system here.

O., Martins Ferry—Meister Coal Co. having preliminary plans prepared for the construction of a power plant. Estimated cost to exceed $15,000.

O., Steubenville—City Council plans to extent water service to west end district, including 300,000 gal. tank, pump, gate valves, etc. Bids will probably be advertised this summer. Estimated cost $107,347. James K. McGinnis, Steubenville, is engineer.

Pa., Philadelphia—Philadelphia Electric Co., 1000 Chesinut St., awarded contract for a 165,000 k.w. electric turbo-generator to be installed in the generating station on Delaware River, Richmond, to Westinghouse Electric & Mfg. Co., Walnut and 30th Sts. $8,500,000.

Tex., Eagle Pass—Crystal Ice Factory, c/o A. Kifuri, will build a 1 story, 60 x 90 ft. ice factory. Work will be done by day labor. Estimated cost $80,000.

Wis., Oshkosh—City having plans prepared for intercepting sewers and pumping station. Estimated cost $200,000. Pearse, Greeley & Hansen, 6 North Michigan Ave., Chicago, are engineers.

Wis., Portage—City Council will receive bids until July 19 for the construction of a sewage disposal plant including pumping station and screen chambers, sludge pumping equipment, etc. Estimated cost $40,000. H. V. Tennant, Portage, is city engineer, and Pearse, Greeley & Hansen, 6 North Michigan Ave., Chicago, Ill., are consulting engineers.

Ont., East York—Township of East York plans to extend hydro-electric services, to include poles, insulators, etc. Work will be done by day labor. Estimated cost $50,000. G. R. Jack, 443 Sammon Ave., Toronto, is engineer.

Ont., Toronto—City, will receive bids until Aug. 9, for the construction of a waterworks filtration plant at Victoria Park, incl. screen and chemical building, connecting to new intake tunnel (already built), building containing low lift and high lift pumps, controls and suction well; coagulation basins, offices, laboratory, reservoir, filtration plant; constructing reservoirs, footings, basins, etc., electric light and power, steam heating, interconnecting piping of steel and concrete valves, meters, etc.; bids July 26 for equipment. $3,000,000. Plant is part of new duplicate waterworks system. Capacity for 100,000,000 gal. to be installed with provision for 300,000,000 gal. Total cost $14,500,000. R. C. Harris City Hall, engr. Gore, Nasmith & Storrie, 1150 Bay St., consult. engrs.

Equipment Wanted

Diesel Engine—Gridley, Calif.—City plans to purchase a diesel engine.

Pump—Boston, Mass.—J. A. Rourke, Commissioner of Public Works, City Hall, will receive bids until Aug. 3 for a new 12 in. pump for Calf Pasture pumping station (sewer division).

Pump—Sauk Rapids, Minn.—City plans to purchase one pump, probably a 500-g.p.m., 50 hp. motor.

Power Plant Equipment—Piqua, Ohio—City, c/o Board of Commissioners, will receive bids until July 20, for electric distribution system, switchboard, pumps, crane, coal handling equipment, etc., for power plant. Will probably take bids on building in August. Burns & McDonnell Eng. Co., 406 Interstate Bldg., Kansas City, Mo., are engineers.

Boiler—Salem, Ore.—Board of Control, W. Einzig, Secy., Capitol Bldg., will soon call for bids for a new 250 hp. boiler for heating at State Penitentiary. Estimated cost not to exceed $20,000 installed.

Pumping Engines—Norfolk, Va.—U. S. Engineer Office will receive bids until July 15 for constructing and delivering 2 triple expansion pumping engines.

Booster Pump—Fond du Lac, Wis.—City plans to purchase a booster pump for waste tank handling fluid from tannery. Geo. Stanchfield, City Hall, is engineer.

Electric Motor—New Toronto, Ont.—Donnell & Mudge, Ltd., are in the market for a 7½ hp. electric motor, 25 cycle, 3 phase, 55 volts.

Transformer — Wellington, New Zealand — Secretary of Public Works and Tenders Committee will receive tenders until Sept. 15 for one 1,500 kva. 3 phase transformer including "Buchlotz" relays and spares.

Diesel Engines — Stockholm, Sweden — Florman & Co., Birgerjarlsgatan, 6, in the market 7 diesel engines.

Motors, etc.—Oslo, Norway—E. Bjornruds Maskinfabricks Utsalg, Skippergaten 44, in the market for at least 100 electric motors ½ hp. to 40 hp. 220 v., 1,000-51,000, rev. Cable address "Bjornrudverk."